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FRONTINUS

AND

THE WATER SUPPLY OF THE CITY OF ROME

CLAUDIA AND ANIO NOVUS.

"If he will note the high aqueducts required for maintaining the proper elevation." — Pliny, *Nat. Hist.*, xxxvi. 24.

Claudia built of dimension stone; Anio Novus, built of small stone and concrete, on top of it.
The Alban Hills in the background.

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THE TWO BOOKS

ON

THE WATER SUPPLY

OF THE

CITY OF ROME

OF

SEXTUS JULIUS FRONTINUS

WATER COMMISSIONER OF THE CITY OF ROME
A. D. 97

A PHOTOGRAPHIC REPRODUCTION OF THE SOLE ORIGINAL LATIN MANUSCRIPT, AND ITS REPRINT IN LATIN; ALSO A TRANSLATION INTO ENGLISH, AND EXPLANATORY CHAPTERS, BY

CLEMENS HERSCHEL
HYDRAULIC ENGINEER

SECOND EDITION

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Ἄριστον μὲν ὕδωρ.
The chief thing is water
PINDAR (522–c 441 B.C.).
Olymp. i. 1.

LONGMANS, GREEN, AND CO.
FOURTH AVENUE & 30TH STREET, NEW YORK
LONDON, BOMBAY AND CALCUTTA
1913

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1913

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JOHN WILSON & SON, CAMBRIDGE, U. S. A.

Quid loquar aerio pendentes fornice rivos
Qua vix imbriferas tolleret Iris aquas?
Hos potius dicas crevisse in sidera montes.
. . . . . .
Intercepta tuis conduntur flumina muris.
Consumunt totos celsa lavacra lacus.

RUTILIUS NAMATIANUS, (A. D. 416),
Iter ad Ven. Rufium, 97–102.

Why should I mention the aqueducts, sustained upon lofty arches, to which Iris could scarcely lift the waters of the clouds? One might say these were mountains that had grown starward.

. . . . . .

Rivers are intercepted and hidden in thy walls. The lofty baths consume the whole of reservoirs.

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INTRODUCTION

INTRODUCTION

Trahit sua quemque voluptas.
Every one has his hobby.
VIRGIL (70–19 B. C.) *Buc.* ii. 65.

Content, if hence th' unlearn'd their wants may view,
The learn'd reflect on what before they knew.
POPE (1688–1744), *Essay on Criticism*, iii. 180.

Indocti discant et ament meminisse periti.
C. J. F. HÉNAULT (1685–1770), *Abrégé Chronologique*, i, 1.

THE object of this book can be briefly told. Having had the study of Frontinus for my pastime and hobby for many years, it has seemed to me fitting that others should be enabled likewise to partake of the instruction and pleasure this study has given me. Especially have I desired that my brethren of the profession of the Civil Engineer should have this opportunity. They have but little time and are seldom led to look up ancient history, or to read the "humanities," and are likely, therefore, to take all the more pleasure in what one of their number has culled and distilled for their delectation from these sources. In a few days they may thus enjoy what it has taken him years to collect, order, and present.

Other readers also may be pleased with the book. Though Frontinus' "De Aquis" was translated into French by Rondelet, in 1820, and into German by Dederich, in 1841, I know of no other translation than this into English. Yet the subject matter is one that I have found to be of interest to very many kinds of people, professional men and others, a multitude of whom have been shut out from the pleasure of reading our author so long as he has been immured in the Latin tongue. And they would continue to be thus shut out unless a

translation made the pleasure I have referred to possible to them. After the momentous experience of the Reformation as to the benefits to be conferred upon the mass of the people by translations, it should need no argument to justify their value in our day.

Nor need Latin scholars, who, as a rule, take no interest in translations, look askance at this edition. For the express purpose of winning their favor I have gone to great trouble and expense to procure for them a reproduction of the sole original manuscript, never before published. In the reprint of the Latin text I have followed Bücheler's 1858 edition, except in a very few places, made clearer by the labors of others since 1858, and so noted.

Lieut. George H. Derby (1823–61), Engineer Corps, U. S. Army, perhaps better known as "John Phoenix," in his essay, entitled "A New System of English Grammar," makes the suggestion that our language is too colorless: that, for example, there is apt to be a great difference between one good man and another good man; that all adjectives should therefore be graded, say, on a scale of 100; so that one man would be 25-good, while another would be 10-good, or 70-good; and so on. Similarly it has appeared to me that the age figure and other attributes of an author need revealing to, and classification in, the minds of his readers, to enable them properly to estimate the value of such author's writings or opinions. Indeed we have for such a procedure the example of the great Augustus Caesar, in his Ancyrean inscription, — "I was in my seventy-sixth year," says this masterpiece of imperishable literature, "when I wrote these things." And how often do we not gladly read "some account of the author," on the first pages of his works.

It is in this spirit and for the purpose named, that I now give my age as fifty-seven, and my life's occupation that of an hydraulic engineer. I am not a Latin scholar, having forgotten nearly all the Latin I ever knew, and that was never very much. But as I fluently read and speak French and German, as well as English, I have had no lack of translations of Latin authors to cull from. Whenever the French and German translations agreed, a fair measure of proof was thereby furnished that the translation was correct; whenever they differed, and such cases have been few, I have had recourse to friends, more

learned in Latin than I. Especially has the splendid work of one of these, noted later on, been of material benefit to this book on these lines. But when it was a question of rendering into English some phrase or sentence relating strictly to applied hydraulics, my engineering experience has stood me in good stead, and has made me well-nigh independent of languages. The reader may be assured that there has all along been a marked bond of sympathy, caused by their common professional employment, between the Latin surveyor and water commissioner Frontinus, the French architect Rondelet, the German builder Dederich, and the American engineer-author of this book. We have understood each other quite well, even in places which the world at large has passed over without understanding or appreciating.

Finally, should it to some seem presumptuous in one not a Latin scholar to have undertaken this work of giving Frontinus to the English-speaking public, I pray them to consider that we laymen have been waiting a long time for Latin scholars to do this thing for us, and they have not responded. They seem to consider the work of translating from the Latin as out of their especial line (note that all the translations of Frontinus have been made by architects or engineers), while some have spoken rather scornfully of our author as though he were not worth the reading in any language. Says Duruy,[1] in his magnificent "History of Rome": "Columella, Pomponius Mela, and Frontinus have left some valuable remarks on agriculture, geography, tactics, and aqueducts; but their books belong to the class which furnish facts without giving ideas." One object of the present work is to present our author to the largest possible circle of readers, and to remove such a depreciatory idea of Frontinus. It may yet appear that he is well fitted to give many and valuable ideas to the careful reader. One has but to listen carefully, to put one's ear down close to his little book on the waterworks of Rome, even if his other works are not hearkened unto, to gain much information and instruction, and perhaps some ideas.

I also wish at the very outset to justify the use in these notes of the personal pronoun. To any one conversant with foreign literature,

[1] Duruy, *History of Rome*, Boston, 1886, iii. 6, 340.

the labored and strained avoidance of the word "I" in English writing must often appear affected. There is no such thing in French or German literature, and presumably would not be in English except for the accident of the word "I" being written with a capital letter. Your German or French author talks to one in the first person singular and as a friend, whenever he feels so inclined, and with the friendly feeling which I entertain for all who may read these pages, any subterfuge of the usual English sort, from the involved sentence in the nominative case to the ridiculous assumption of the "we," would have seemed wholly out of place.

Let us now begin at the beginning and see what there is upon which to found our knowledge of this essay of one Sextus Julius Frontinus on the water supply of the City of Rome.

A fortunate circumstance — fortunate as simplifying our labors in the task of establishing proof from testimony — cheers us at the very outset. In the undisputed opinion of the best students of Latin manuscripts, there is but one original codex of Frontinus' "De Aquis." All other manuscript copies in existence, all printed copies in existence, can in their origin be traced back to the precious twenty-two and one half pages of parchment of Frontinus' "De Aquis," originally written at and still kept in the library of Montecassino, a Benedictine monastery, situated on a mountain top lying between Rome and Naples, and about equidistant between the two. It was my great pleasure, Nov. 22, 23, 1897, to examine this manuscript, having made a pious pilgrimage from New York to Montecassino for that express purpose, and to enter upon the personal relations with the Benedictine brethren of the monastery which caused them finally to allow me to procure a photographic copy of it.

Professor Bücheler, of Bonn, has called the Montecassino codex the sole original manuscript in his 1858 edition of Frontinus.[1] Oct. 28, 1897, he expressed himself to me to the same effect in the most positive terms, and I believe this opinion is not questioned. More uncertainty exists as to the age of the Montecassino manuscript. The present learned librarian of Montecassino, Ambrogio Monsignore Amelli, judges the body of it to be in the handwriting of Pietro

[1] *Iulii Frontini De Aquis Urbis Romae, Libri II.*, Leipzig, 1858.

Diacono. If so, it dates from the twelfth century, for Pietro Diacono was chief abbot of Montecassino in 1168–1170. The learned Professors Bücheler and Petschenig ascribe it to the thirteenth century. Perhaps its age, within a hundred years or so, matters little. It is more important to note that it was evidently copied from a manuscript written in the older uncial letters which were the prevailing hand from the fourth to the eighth century,[1] and that this older manuscript was defective at regular intervals, presumably where it had been worn at the top and bottom edges of the pages; and still more important is it to remember that a manuscript of the twelfth, or of the thirteenth century, of this work which was composed in the first century, contains, in all probability, many errors produced by repeated copying, and not chargeable to Sextus Julius Frontinus, its author.

Having gotten rid of all manuscripts except the one of Montecassino as testimonies to the truth, we get rid with them of that delight of Latinists, the "collations," or comparisons, one with another, of the several manuscripts. Of course they differ, but this only means in our case that the new ones contain errors wherever they differ from the Montecassino manuscript, and these errors we surely need not preserve. It is fair to add, however, that "collations" also contain suggestions from the learned, studious, and ingenious as to corrections to be supplied to make sense of palpable errors; also as to syllables, words, or phrases to fill up blank spaces found in the original copy; and that this much should be saved from the lot. Anybody who has had experience with the natural perversity and tendency to error of that very perfect machine, the modern type-writer, and of its operators, will not wonder that manuscripts could not practically be reproduced by the much more difficult process of penmanship. Nothing but a photographic reproduction can be relied upon to do that.

The temptation has been great to be led on, from allied subject to allied subject, until this book might have contained a treatise on Roman History, on the lives of, and on life among, the Romans, from the foundation of Rome 753 B.C. to the present day, and this temptation

[1] *Latin Manuscripts*, Harold W. Johnston, Chicago, 1897, § 99.

had to be resisted. I have, therefore, excluded a consideration even of Roman aqueducts other than those described by Frontinus, and have as a rule confined myself to a consideration of men and things as they were during the lifetime of our author. On the other hand, my endeavor has been to find out the truth about the subjects that Frontinus presents for our consideration. No one can get very far, in the attempt to state facts on subjects of this sort, without recognizing that the world of authors is sadly given to compiling, and, as a means for the spreading and the perpetuation of error, such a method of work is nearly as efficacious as wilful lying.

One branch of archaeology consists of the identification of ancient localities. This has become a life study with some exceedingly able and learned men at the present day, and most remarkable work of this kind has been done in modern times. As especially important in this line, I mention Lanciani's "Forma Urbis Romae," an archaeological map of the city, in forty-six sheets, scale 1-1000, published in Milan: a monument of learning and of patient research, and the outcome of generations of archaeological study, and of the records of the accompanying excavations. In this line I make no claim to have done anything at all, except to make use of the writings of others. But those writings, and especially the latest maps and treatises on the ruins of ancient Rome, leave but little to be desired by the earnest scholar.

At the risk of being chided by some as unscientific, I have adhered to the use of English measures of length, weight, and capacity. I recognize the superiority of the metric system, but this book is written for English-speaking people, especially for Americans, and so long as a complacent Congress does not compel the use of the metric system in the United States, it will probably never be introduced here; and one object of this book is to please readers under the existing conditions of men and things.

An excellent list of books, with their descriptions and prices, relating to all branches of archaeology, necessarily including the very small branch or twig of archaeology herein treated, may be found in "The Journal of the Archaeological Institute of America," 1897, No. 2. Some of the books described in this list have been used in the preparation

of this volume, and as they will frequently be referred to, are here cited, using the above-named journal list for their description: —

G. BOISSIER: *Promenades archéologiques — Rome et Pompéi.* Paris, 5th ed., 1895. 16mo. pp. vii, 408. 70 cents. Delightfully written sketches. The English translation, which was published in 1896, is inaccurate, and should be avoided.

R. CAGNAT: *Cours d'Epigraphie latine.* Paris, 2d ed., 1890. 8vo. pp. xxvi, 436. $3.00. An excellent treatise by a masterly hand, but needs to be supplemented by a collection of specimen inscriptions.

A. CHOISY: *L'Art de bâtir chez les Romains.* Paris, 1876. pp. 216, with 24 plates. $12.00. Important treatise on Roman concrete vaults, by a civil engineer.

Corpus Inscriptionum Latinarum. Berlin, 1862, ff. Cited as C. I. L. 15 vols., folio, some volumes in a number of parts. Price, as far as issued, about $350.00. Detailed description may be found in most of the books on Roman Epigraphy mentioned elsewhere. It is now approaching substantial completion, and is, of course, the one monumental work in its field. Supplements to some of the volumes have appeared in the *Ephemeris Epigraphica*, which is published at irregular intervals. Newly discovered inscriptions are constantly appearing in the periodicals devoted to classical archaeology, and a convenient summary of them is published by R. Cagnat, as an appendix, in each volume of the *Revue Archéologique*, and also separately as *L'Année Epigraphique*, since 1888.

CH. DAREMBERG et E. SAGLIO: *Dictionnaire des Antiquités grecques et romaines.* Paris, 1873. I. A–C, pp. 1703; II. D–G, pp. 1716; III. In course of publication. $24.00. The most comprehensive of its class. Fully illustrated.

H. DESSAU: *Inscriptiones Latinae Selectae.* Berlin, Vol. I., 1892. 8vo. pp. viii, 580. $4.00. Contains 2956 specimen inscriptions. The best collection of selections, so far as it goes. The second volume is promised speedily.

J. DURM: *Die Baukunst der Etrusker und Römer* (in his *Handbuch der Architektur*). Darmstadt, 1885. pp. 368. $5.00. A systematic treatise on Etruscan and Roman architecture.

H. KIEPERT and CH. HÜLSEN: *Formae Urbis Romae Antiquae.* Berlin, 1896. $3.00. Three maps, with full topographical index, prepared under the direction of Dr. Hülsen, second Secretary of the German Archaeological

Institute in Rome, and embodying the results of his long and able investigations. The best archaeological map of Rome for the student, and indispensable.

R. LANCIANI: *Ancient Rome in the Light of Recent Discoveries.* Boston (and London), 1888. pp. xxix, 329. $6.00. Also *Pagan and Christian Rome.* Boston (and London), 1892. pp. 374. $6.00. Chapters from the history, topography, and life of the ancient city, charmingly and vivaciously written, by one of the best Italian authorities, and issued in two beautifully made books, well illustrated. No scholar can afford to omit the reading of them, though some of the theories held by the author are strongly contested.

R. LANCIANI: *Forma Urbis Romae.* Milan, 1893 f. An archaeological map of ancient Rome, with outlines of the modern city, on a scale of 1-1000. The work, when complete, will consist of 46 plates, each about 26×37 inches in size. By the use of different colors, and by inserted notes, a large amount of information is clearly and conveniently presented. This is the *magnum opus* of its author, and an important help for the advanced student of Roman topography. Five parts have thus far been issued, each containing six plates, at the price of $5.00 per part.

R. LANCIANI: *The Ruins and Excavations of Ancient Rome.* Boston, 1897. pp. xxiv, 619. With 216 maps and illustrations. $4.00. Contains brief, but excellent bibliographical hints on each topic, and is probably the best general handbook for students' use yet issued.

J. MARQUARDT: *Das Privatleben der Römer.* Leipzig, 2d ed., revised by A. Mau, 1886. 8vo. pp. xiv, 887, with some woodcuts. $4.50 ($3.25). With full references. The best book on the subject.

A. MAU: *Führer durch Pompeii.* Leipzig, 2d ed., 1896. 16mo. pp. 113, with plans. 67 cents. An admirable introduction to the study of the existing remains of Pompeii, by the best German authority on the subject.

J. H. MIDDLETON: *The Remains of Ancient Rome.* London, 1892. 2 vols. 8vo. $6.25. Supersedes the author's earlier work, *Ancient Rome in 1885.* A systematic treatment of existing remains, by a trained architect as well as art student. Amply illustrated. Some of the theories held by the author are disputed.

A. SCHNEIDER: *Das alte Rom, Entwickelung seines Grundrisses und Geschichte seiner Bauten.* Leipzig, 1896. Folio, 12 pages of introductory text, one map of the modern city, on cardboard, and 12 of different stages of the ancient city, on tracing paper, for comparison by superposition, and 14 plates, with 287 illustrations. $4.00. An adequate pictorial summary of nearly all that is known of the ancient city.

W. SMITH: *Dictionary of Greek and Roman Antiquities.* Revised by W. Wayte and G. E. Marindin. London, 3d ed., 1890–91. 2 vols., pp. 1053, 1072. $16.00.

VITRUVIUS: *De Architectura,* ed. V. Rose et H. Müller-Strübing. Leipzig, 1867. pp. 319. $1.75.

G. WILMANNS: *Exempla Inscriptionum Latinarum in Usum praecipue Academicum.* Berlin, 1873. 2 vols. 8vo. pp. xvi, 532, 737. $5.00, $4.00. Gives 2,885 inscriptions of all classes, with brief notes, and very full, classified indices. The selection by Dessau, when completed, will supersede this.

Other books referred to are:—

ALFRED LEGER: *Les Travaux Publics aux Temps Romains.* 1875.

CURT MERCKEL: *Die Ingenieur Technik im Alterthum.* 1899.

Both these books were written by civil engineers.

MORITZ CANTOR: *Die Römischen Agrimensoren.* 1875. Treating chiefly of their mathematical knowledge.

MORITZ CANTOR: *Vorlesungen ü. Geschichte d. Mathematik.* 1885. A most noble work.

PAUL DE TISSOT: *Etude, &c., sur la condition des Agrimensores, &c.* 1879. Containing also a bibliography of the subject. Excellent.

F. STOEBER: *Die Römischen Grundsteuervermessungen.* 1877.

Another excellent list of works, ancient, mediæval, and modern, relating to the archaeology of Rome may be found in the first volume of "The Remains of Ancient Rome." J. H. Middleton. 1892.

The pleasant duty remains for me to make the proper acknowledgments for aid given me in the preparation of this book, and I hardly know whom to name first. I will commence with those living abroad. Professor Gatti of Rome, Sig. Jules de Petra of Naples, Professor Lanciani of Rome, I have referred to in the text. Dr. Nevin of Rome, and Padre Ehrle of the Vatican Library, greatly helped me. Without the active aid of Samuel A. B. Abbott, esq., of Boston, Mass., exercised after my departure from Rome, I doubt if I should have succeeded in presenting to the reader the reproduction of the manu-

script of Frontinus' "De Aquis;" and the reader's thanks for this are equally due to Mgr. Amelli, Librarian of Montecassino; not to speak of the thanks due to generations upon generations of the Benedictine brethren of Montecassino for all they have done to keep alive and further literature, art, and science, their work on our little book inclusive. Prof. Charles E. Bennett, of Cornell University, Ithaca, N. Y., gave me active aid, countenance, and encouragement at every stage of the work, and ended off by reading the proofs and correcting the copy of the translation to an extent that makes the translation fairly his own. Let no one attempt to scorn or criticise the Latin work in this book in the vain belief that necessarily I did it. If he does, he may unwittingly catch, if not a Tartar, at least a thorough Latinist.

I would thank still others, were I to reveal the whole history of the making of this book.

C. H.

2 WALL STREET, NEW YORK CITY,
March, 1899.

PHOTOGRAPHIC REPRODUCTION OF THE MONTECASSINO MANUSCRIPT OF FRONTINUS' "DE AQUIS"

NOTE

The following words in the original Montecassino MS. are written in red ink. In 1897 these were still of a bright red color.

Page I. Incipit prologus Julii Frontini in libro de aqueductu urbis Romae.
Explicit prologus. A

Page X. Liber primus explicit. Liber secundus incipit.
Appiae.
Anioni veteri.
Marciae.

Page XI. Tepulae.
Juliae.
Virginis.

Page XII. Alsietinae.
Claudiae.
Anio novus.

Page XIII. ex eo.
ex eo.

Page XIV. ex eo.
ex eo.
ex eo.
ex eo.
ex quibus.

Page XX. Was evidently written by a different hand from that which wrote the preceding pages.

Incipit prologus iulii frontini in libro de aquaeductu urbis romae

[illegible]

Explicit prologus. [illegible]

[illegible]

Incipit appia. [illegible]

gentos quadraginta. ope arcuato passuū septingentos aquā
monūduct. Rauſalbo rminer efficiunt passus mille quadrin
gentos quinq. Quae ratio mouit augustū prudentissimū prin
cipē pducendi alsietinā aquā quae nouacta augusta. Alsiens
ſpacio. nullius grauit. minio erā parū salubrē. dein q̄ nul
lius usus populi fuerit. nisi forte eo q̄ naues ad eum egredi
nequid salubrioribus aquis deterreret. hanc ppria ope pduxit.
q̄ naumachiae cepta fuerat. horas adiacentibus. ꝙ priuatos
usus ab his adirigandū cessit. solet tamen ex eā vinū ybernā re
gione quotiens pomis refici. ꝙ ac uitiorem ripa aquae cessant
ex necessitate in subsidiū publicū salubrem dari. Concipit
Ex lacu alsietino. via claudia. miliario quarto decimo.
de uiculo dextrorsus passibus ex milibus quingentos. Ductus
eius efficit longitudinē passuū undecim milia centum. ex quibus
septuaginta duos. ope arcuato passuum trecentos quinquaginta
octo. Idē augustus in subplendis tiburtinis marcianis aquis
agrippae aquis usus aliam earum deprehensas ope subterraneo p diuer
sus ad uillas eorum. q̄ ab iuentore appellat augusta. nascen
tes ex fontibus martis. cuius ductus donec martia accedat. cessat
passus octingentos. Postea. c. coepit q̄ uberiores successerit. cū puri
& publicis usibus & priuatis uoluptatibus. septē ductus aquarum in ur
bem ferant. alterum in ianiculum. Cl. Aquila iuliano. P. nomio adpre
nato cos. anno urbis condite septingentesimo nonagesimo.
duos ductus in choatu. q̄ op. claudius magnificentissime ſtū
mauit. dedicauit. sulla & pisone cōsulib. anno q̄ urbē dein
octingentesimo sexto. setia augustalis. alterum nomine ex fon
tibus cęruleo curtio pducebant. claudia deprehensa & ſ
gimae sit martis alterum quae nō duxerant. nisi murbe capsuere
ejusdem. ut dictitassent appellationibus diuersis cerni. Simonis ne
bris accepit. alia omissa procedit. priori simo uicogemmucerino
recta. Claudia cōpta una sublacensi adhibetur ꝙ uetus
tissimorum. de uiculis imissus in septimum ex fontibus
dulcibus amplissimus & speciosus. cerulea similitudine malpellae
ita accepit. ex fonte quod albudinis. tanne bonitas
ad mare ex quo adductor quotiens opus est ostiensi cuat. ad
adiectione ex nichil ex qualitate eius mutet. Aqua sue
tonius quia martia subiunctis ubi parebant. Claudius dein
manentibus nouis. priuatorum ductus. ꝙ ac uitiorem
aquā adiuuaret augusta. sed ductus marcianae caput. Clau
dii ductus habet longitudinē passuū quadraginta septem milia.
Ex eorum subterraneo passuum triginta septem milia ducentos sep
tuaginta. Ope super terrā passuum decem milia. sex hu septuaginta ex
quo opere arcuato ubi saepius per plurimos locis passuum mille
septuaginta sex. & per urbē ab septimo miliario substructio te
nuis & passus sexcentos nouē. ope arcuato passuum sex mi
lia quadringentos nonaginta quinq. Inter ostiensia sub
lacc[illegible] stadium miliarium quadragesimum sextum ubi
Ex[illegible] p̄ existimauit. q̄ citra ostiensem casas habeat.
solu[illegible] pingues. & ideo passuum ferè trecentorum ſ

imperialium aquarum fluxum. ideoque aquaeductu interpositae
pisculinarum ubi terrarum ipsi specu ipso fieri aliquando quia siquoque
quoties imbres supervenerunt. ibidem supervenit urbem. Jungitur
cruus herculaneus forum cedens. admiranda rerum multarum aggre
gorie formidandae ruinae fluxum. undique naturae possim, ipsum usus gra
splendentissima auctoritate. Ductuum nisi rem efficit possunt quia
gratia eo multis pragmatos. quorum sub terra dispositum quia
dragmata eo multa recenso. quae sub terra pluvium noctu multa
quadragenos. quae sub structionibus, undique caeruleo scripturum
pluribus locis pluvium duodecim multa recenso. ipsum urbem septimo
maiore sub structione rumque passus quae centos octo. quae caeruleo
passuum ex multaque dragenos nonaginta unum. hysium altissimum
altissimum sublevamus, ditiores pedes centenos nonos. Tot aquarum — 16
multis necessariis molibus pyramidas undeducentos ostenderet quod
centum thermas, fama celebratas aegregios. Non alienum mihi videtur — 17
longitudines quoque rumque cuniculi ductus. erunt species ego complecti.
nec ima rum hyemis officia partes tutelae quae sed quoque postilo per
rectae quemadmodum pendia pagum. Hinc de solutum undum illustrium
singula octo sub ipsa esse formis quae ductum fuisse caerulea. quibus
aberat unda lesque rep. ubi sumina tectae. unum vitiebus
species ad plenae. maior dari duas parendi ac mimo dum gregum
cum. hyemis latae ang. lucrum ad restarum melum esse pendebe
possimus. deliberare quid fieret. Omnes quoque fuisse — 18
urbem libra pruenum. Indesum quae alia rum locis quae tergi
nem nec non rum possunt. nec collessi sunt. praeterea rum cen
duque quae cum. nudeque quae sum dum tale rum nec non quae
urbis ad tollit. si quis haec memoria tale rum fuisse
altissimus admonuit. quia ad laudatum locum nec
tum. ut pula deinde marcia. quae caput erat claudia liber aequam
quem si humiliore decem duplicem. sive id dum ad supplo
mentum tribunal. seu quid usus fuisse tum aqua rum. —
ne facul abhos inby tore quae. cum quae rum ad hucdem quae
cos bellagere rem. utrum quae si locus sua ab ducta fuerit care
dilapsus. omisso circuitu sub terraneo valli. hremonta ex aus
sub structionibus arcuationibus quem rum. quae tum
lectiones. similes fuisse rum. erat alterum locis
nullam ostium si quis rogatum celsicao quae. sub structionibus arcu
ationibus ne si erigere. Sed hunus libra rum ergo. de deppia
quem quae rubana aggre ducta. ex framed altitudinis ergo pro
mer. Omnibus humiliora altis pruma. quem rum si ubernacula
ony maxime iacentibus locis esse rum. Quisque unum — 19
nam milium ex vetus piscinum excipiunt. ubi quae si rum pinnum
rumque cursu. humidae pennum. modusque eum assimilibus
depositis nec. unum ex eum nullam arcuatae pilae quae
sicut sub demonstratum, eum nullum ecclesiae ex aedificiana
nullum modi accepit. aggressa cum, pronuntiarunt. hoc est
apis omissa ecclesiae dearcuatae quum. sum hysulio. Verum
repulae. de marcia quae libri mirabilis rec
a ex est adumminatis quae deuenum. ibi cursu emer
gunt. pruscatum pars ulcus alsphaeretum quae pa. cubellu colu
mere si diffundit. marcia aparellum hortos pal

VI

ĩmũquo cat̃ hercul aneus deret ĩ pe cel uũ duer̃ ꝓ sus mo ens
usibꝫ. mchil ud ĩferior ſũ mi ſtrans. mi ſup̃ poñ t̃ expenſ.

20 Agrippa uſ; claudia aq ſam ĩ mate ro ſa rcus recup aret. mand
ſupior lit amo. fimum t̃ arcus t̃ arũ ꝑ hortos pallantanos. ꝑ
deinde ſũ urbis ſiſtens ſi chduam t̃. partẽ t̃ aũ ſi ue claudia pruſ
uia rcus quo cat̃ neronian. ad ſp uerẽ t̃ ĩ ſtruere. hdrian
ꝑ cel uũ mouit̃ uix ntẽ plũ dum claudi rẽ minuere. modũ que
acce ſſum aud curaſſimont̃. aud ĩ pilarũ altitudinẽ q;
21 - ꝓ regionẽ ĩ ſtybꝫ ꝓ nidimidium. Agrippa uer̃ cũ q; arũ
mil iarũ ĩ trans mo ue qua lia mĩ l iaria ĩ t̃ arcu ſ; ſeruare.
ꝓ ipſe piſcinã habere. ſcdm̃ ſecundũ mil iarũ ꝑ t̃ ẽdat ĩ ſpecũ
quo cat̃ ocriculanũ. ꝓ puenit ĩ regionẽ ſeptẽtrionalẽ. ad ſeptẽ ſol i
anos. ũ ꝑ pullũ t̃ erũ ĩ undiſtribuit ur. reet uõ ducẽ ſ; ſecũ
ſpẽ uenient ſ; ĩ ꝓ ora t̃ eq; ſtrũ. malos ſtruos ꝑ urbẽ ad ducant.
22 Nec uirgo. nec appia. nec alſietina ĩ cepta cula deſt pſtant
habent arcus ſ; urgus ĩ mtrũ. habent ſ; iborti ue tus ſ; ſi mi
unt̃ ĩ t̃ a pomerio. ſecũ ſ; infrontẽ ſ; ſepoq; t̃ uo lappies ſub
cliuo monte. ſ; ſie ſtimoac̃ emer git. addyrm ĩ ſtim ad ſi mũ pu
blicũ ad ſi. ꝓ me ducẽ ꝑ mumadiã q; cuniculi ſ; ſub urbẽ. ſ; fac̃
23 ſimt̃. Quoniã auctoris cuiuſq; aque ꝓ ue nerit ſpẽ ordines
ꝓ longitudines ſui. ꝓ ordinẽ libꝫ ꝓ ſcripſimus. Nondum tñ
modum diſcuſſerẽ t̃ ra ſingulas ubicẽ. ꝓ ſtrendẽ q; uam ſ; dco
piaq; publica ſ; priuatis ꝓ ſũ ſolũ ubꝫ. ꝓ aqueductus. ũ mercatũ uolup
4 tatibꝫ ſufficiat. ꝓ pg ca ſtella ꝑ gregionibꝫ dedu cat̃. quanta
q; extra urbẽ. quanta ũ in urbẽ. ꝓ ceo quimũ lacubꝫ. quam ſtum
nibꝫ. quam ũ ꝓ ſiꝫ publicis. quam ũ ñ ſ; nece ſſarijs. quantũ priꝫ
uatis ſ; ubꝫ erogẽt. Sed rationẽ ſ; exiſtimo prudẽ nomina
quam q; arũ cẽmenariũ q; certum modulaq; ꝑ quas mĩ ſtra
ẽ ſtimacẽ ꝓ ferant. ꝓ dicare q; ſit eaq; origo. q; uare ꝓ ; q; id
que appellatio ſignificet. ꝓ poſtea q; regula adquã ſtructo
eaq; ꝓ ſtructũ ꝓ ſimt̃. ꝓ ſtrendẽ q; ſi quis me diſcere q; ſcta
24 ĩ cepimus. quã ẽ ñ ſ; ad duas ſi mſcim̃. A quarũ modulus ad
addigtẽ. nn ad ducta ſũ ũ ĩ ſtitutũ ĩ ſtitutionẽ digitũ
punctũ. ꝓ plerꝫ q; mutata locũ ſimẽ ꝓ pria cum hac obſeruãt.
Cruũ digitus uidẽ ſ; eſſe ſex decim partes pedis. unciã
duodecim. quãdam modũ ãt ĩ ſtitutũ digitũ uidẽ ſ;. ma
ꝓ ipſum digitum ſimplex obſeruatio ẽ. Alius locat quadrãtẽ.
alius rotundus quadrãtẽ. tribꝫ quarta ſe cum mĩ ſtrum
do. maior rotundus tribꝫ undecim mĩ ſtris quadrantem minor
25 eſt. ſi ducat quinq; guli dẽtẽ ſunt. Poſtea modulus nec
abunci. nec abſtet ſtructo digitoq; a rigine accepimꝰ. ĩduct
ũquidã pinzon. ab agrippa ũ alui aplũ ſtrum ſtructũ
architectũ. inuſtũ rubꝰ ſyculus ſ; priorib; ſuis. appellat
quinq; nomine. Q uia ũ agrippi aucto rẽ ſacrum. dicẽ
q; q; ſ; ſ; magmodulo ẽ rile ſ; ſtuelut primeq; ſ; ſi magn
cũ exiguẽ ẽt dumdebat. ſmmũ ſtrul ſ; ſuum. Pu
ſtrum ũ ſ; plũ bariosq; abeo q; plũ bedi mmẽ ſ; ſ; q; nque
digitos ſ; t̃ ra tudinẽ habeat ſ; ra ſ; ſ; rotundũ. hunc ſ; ſ; ule
modulũ eſſicunt. ſ; hoc ſ; certũ ẽ. q; ñ ſ; ſ; ra q; ſ; ſ;
ſtructo repu ſ; ſ; ad ſtruat. ſ; ſ; pilla q; ſ; ſ; ſ; ſ; ſ; ſ;
dit. Q uarmq; habile eſt quinarium ducat. ad ſ; ſ; metro.

quinq; quadrantū · quarmoī sequentib; quoq; modulis q̄drati
nariū duarū diametro · p singulos adiectionē singl̄ quadrantū
crescunt uelut senarij q̄ (ex. g.) quadrantes id̄ diametro habet · 7 septe
narij q̄ semē · 7 decē ps̄ imitij crescūt usq; ad uicenariū · Omīs — 26
aūm modulis colligē aut diametro · aut peripheria · aut crece
sure ex quib; capiceps abscree · Differentiā inciedigniqu
drati · 7 digitor mundi · ip sig̃nari edifaciulis dinoscam; uten
diū ē subsequenie gnarie · qui modulis 7 ceteris mī; 7 maxime
cepē · Unicaergo modulis habet diametri digitū unū ·
7 uicenā dignica p̄ plusq; quīq; gnarie eorum · hoc est sesdecima
gnarie · 7 scripulis septē; 7 hoc est scripuli digī quadrat̄ in rotundū ·
redacē · habet diametri digitū unū · 7 digitus ex uicenā septē
capit gnarie de exactē · Digī rotundi habet diametri di
gitū unū · capit gnarie spreuicē semuncā scripulā · ceteri — 27
moduli q̄q; gnarie eorum · duob; genib; ceteris accipiunt ·
7 una cū ipsa multiplicant · idest eodē ut unus plures gnarie
ī duduntē · īq̄b; secūm ad iectionē q̄narii amplitudo
luminis crescit · Cū aūt fert ei usū · aī plures q̄narios
perarere nunc septē uel nouē una fistula · ex quib; ī ca — 28
strellū · ex quo singulis suīs modis recipiunt · Alterū genus ē
quoniēs ñ adq̄narias necessitate · sistulā ī ceteris
capit · 7 addiametri sui simā · secūm · 7 nomē accipit
7 capacitatis ap̄iat · ut puta q̄narias ad iectē ei addia
metrū · quadrantes senarios facit · nec ita ut dictū capacitatē
ap̄iat · capit enī q̄narias una · 7 quincuncē; q̄ly cū ·
7 dei cepsī ad ērationē quadrantib; diametro adiectus
usq; up̄dictū ē · crescunt septenarias octonarias · usq;
ad uicenarias · Subsequit illa ratio · quē sint ex numero — 29
digitor quadrator q̄ren · idest lumine cuius q; modu
ēnce · q̄b; 7 nomē fistule accipiunt · ut q; habet aree
idest luminis ī rotundū coacti digitos quadrates singuli
q̄q; uncē nūq; abpellat · Similit̄ ī septenarias · 7 de
ceps p̄ ceteras · usq; digitor quadratorum usq; ad centenā
uncē · Uicenaria fistula q̄ ī ceteris maxima usq; ad — 30
omis postrema est · cui q; nec ope nec gratia · nec ars · nec ratio
omis possit est · cui q; nec ope nec gratia · nec ars · nec ratio
ēn cō putatione · q; ī precedentib; moduli ostensa est ·
ī diametro quadrate fugiunt · cū diametri eius dē digitis
q̄q; sint · 7 secūm eor; modulor; rationē q̄ sequunt adiect ·
habet digitor quadratorum ex quo minus fugiunt · Ratio — 31
fistulari q̄narior usq; ad centenū uncē · p̄ ostensa mo
dulos ita se habet · ut ostendimus · 7 omīs genē inter se fistulis ·
Conuenit ceteris modulis q̄ cōmunis ut i ceteris · 7 p
ut sum principis · potest · 7 est mensurandi · Suetaque
ratio sue uenit · ad sequendā est · ut ex q; cōmunis q; p
modulis pualem · Sed ad q̄narias manifestē rationi
plurib; ostendam · ī quadrato modulis nouenū ·
duodenarias · 7 uicenarias · 7 centenarias · 7 centū un
cenū · 7 duodenar angulē · nec magis ē error · hoc
ut sit frequens · cum sit diametro adiectum digitus minu
tū · sp; ei capacitatem q̄narie debitē · Reliq; aūt ribi ·

modulus plus deprindē centenariam exiguior ēsentiā d̄ numero
digitos emisse capacitate quam ariston, ꝛ semuncia. quo modulo
plerūq; erogatē. Centenaria aūt ꝛ centenū uicenū q̄b; assi
due actipiunt ñ minimum. ſ augentē. Diametro eī centē
narie adicium digitū bese. ꝛ semuncia capacitatī. quarus
decē semisse semuncia ſ y alicū. Centenoū octono quametro
adicium digitos tres. ſeptunce semuncia capacitatī. q̄ha
33 riasex aguntas ex ſextante. Tradūt aūt centenarie equas sub inde
erogant detrium. aū centarie ꝛ centenū uicenū adici
um. q̄b; ſex accipium. Incipiuntur ī centenaria. qua
rieuq; male pē. ī centenū uicenū q̄narie octogintas ex
uncia. Quod cū ratione ad pbē requoq; ipsam fecisse. nā
p uicenaria quā cesar p q̄narius sse decē assignat. ñ plus ero
gant quā ter deci. Ē ex centenaria quā amplianum
equcesse cū ēillis ñ erogare. nisi adarrio rē numerū.
qa cesar sec̄ms suos cōmentarios cū ex quaq; centenaria ex
pleuit q̄narias octogintas uisse Inē ex centenū uicenū
quinarias nonaginta octo. ut qua ex haustomodulo desint
34 diſtribuere. Insūma modulus sunt modulq; q̄. omēs con
sentium. ꝛ rationi ꝛ cōmentarius. exceptis his quadruor. quos
aquarii nouauum. Cmia aūq; mēsura ctuer cerā ꝛ im
mobilia. ēgruere ibi debent. tra cū unius mēsura ratio con
scribit. Cdquē ad modū ūbi grā sextarius ratio ad q̄ auus.
modiuō ꝛ ad ſextarios ꝛ ad q̄tas ſ respondent. ita ꝛ
narias cumulet plicatio māpliorib; modulis seruare con
sequat ſ uere quā debet. Alio q̄ cū mero gestorio modulo
mus ꝛ iuenit. ñ acceptor eplus ab peret. ēt rore ēesset
35 fraudē. Ꝛ emimam ꝛ omēa aquā quotiens ex oneret
ꝛ ī libreuet. At cū ī castellū cadit ñ tantū ūrespondere
modulo suo. ſ cui ēxuberare. Quoniam ō ex hmiliore
des ſ minsere ꝑ ſ ura longus ducat. ſ egnitia ducē modū
quoq; depdet. Ideo sec̄dm hanc rationē aut onerandā
36 ēerogatione. aut releuanda. S ꝛ posit ēhabet mo
dīuū ī rectū. ꝛ ad libra ēlocat. modus seruatū. ad ar ſ ū
aqueo posit ꝛ deuexus amplus rapit. ad at ꝑ uers
umis aq; cūsus ꝛ ſ upin; id ē ad haustū pnor. ſ egnē ēer
ogatū ſ umit. Cst aū calix modulus eneus. grauot
esse lor debet. huc fistule ēplicant. longitudo eius late debet
digitos ñ minꝰ. duodecī. dum ideſt capacitatē quam impara
fuerit. ērogatus sit deē. quo ārigor erit difficilior ad ſ equā
37 ñtum ꝑ ueniat ēt a pariter coartari. Formulas modulo q̄ sunt
omēs uigintī ꝛ q̄q; subiecti. quāus imus quindecī tantū fre
q̄ntissime dē recta ad rationē de quale cumsumus. ēmēdatas
qui debent quos q̄narios nouauam. ſ ec̄dm ꝛ fistule omēs que
op ſ icant de riq. debent. audi hec fistule manebunt ad
38 quarius quod ſ ap ſ ime cōputatur q̄ ñ sint inusitato dulo.
inspisest ad nouā. ū. Cēl diametri erigonē d̄ q̄tū chica.
quāq; quarie ſ ec̄ uncia. ꝛ ſ cripulus ſ ribi. bes ſ cripuli.
Digitus quadratus i latitudine ꝛ longitudine equalis est.
Digitus quadratꝰ ī rotundū reducē. habet d. amet ri digitū
mū. ꝛ digitus ſ ec̄ uncia cap ſ quinarie. Digit rotundus

X

apē aquarius habebat duarum ridiculos xvij. capacitatis quinarius
centū singularis. ℔ = q̄ mō duarū centenarium ūeho.

liber primus explicit. liber secdus incipit.

64 Per ocul̄ aḡ demodius dicatur necessariū. nē ponā quia modū
quo aquaḡ principalē nūerus eō p̄ ensuē. usq; ad nūm cui nihil
ultra est. quamūq; erogauit. de qua p̄ scripsi ale ḡ sentē
pentē. prudentia opimi diligentissimiq; negotiatoris
usellim. Iuen ḡ cū cōmunis inuenisse quarias decē duo
milia sexcenta octoḡ aquaḡ mero gratione dicō quidem
milia decē. plus tribus hominē acceptō. cōputabat quarius
mille ducentis singularibus. Iussit eā numerare cuīq; ut
officinoq; negotiorū dari quarū adq; copiā esset. nō mo
rātē cū ut adscriberentur. quādmodū ap̄ius erogaret.
quā per nomo. aūt dicā esse. Annotāta atq; cap̄ ad ueniū
mentū aggressus. ſ. longe. ideo circūq; narius decē milibus am
plior. quā ī cō tenarius modū ūnum. ūp̄ singulas demonstrabo.

65. Appias Inō tenarius adscripē modus quarias ōnes engenarū.
Limus tumulo adcapē ūnenū mūsuras ūporum. qm̄ quibus rius
ētur. Adgemellos tamē gloriosē ī ep̄ uerē. ūbrum gē tū
ranoaugustē. Iuenalem tudinē atq; polesq; ī annudinē pedis
unus declarat. Frumar ceperes octo. decimus centenarie
ungmodus. ℞ quadragenarius questicum quarias mille octo
genas ungmq;. Amplius quī cō tenarius habet quarius non
genos octoginta quatuor. Erogabat quinarius sexcentos
quadrus mum; quī cō tenarius adscribē. quarius centum
gmas sep̄ē. ℞ hūc mum; quā adgemellos ūsumeret spondet
quarius mille centū ungmas mutuas fēcidit. tamē aliquantū adhuc
uitio. q̄ quā sit deprehendo. ūsacule manumone sexcentos. quos
esse q̄ adparet q̄ ī plerisq; uribus puribus; p̄bata aqua deser uē
idq; querebat. Set ℞ quasdā siculas ī quarū bōlum uasa defen
dim;. Germanicianū p̄p̄ p̄ hūra libere quā sit mīs. Erāt enī
66 adcap̄ pedibus q̄nquagenis. nullā acceptā iuriā. Annotauerī
Adscribunt ēt cō tenarius modus quarius ūmille quadringentarū
quadraginta unus. Adcap̄ ūtem quadecim mīa centum
nonaginta octo. p̄ter modū q̄ p̄ p̄ruchū ūbrum ūlderunt.
Amplius quī cō tenarius est quarius duobus mīb; octingentis
q̄nquaginta sep̄ē. Erogandū aūq; ī adp̄sentē uenerat qua
rius duce mille septuaginta duo. Modus impositus quīq; ūnus
positus sumē. effecit. quinquarū duorum milia centum
duas. Iuenerā debuit. Ergo ī cap̄ p̄ sumē quinquaginta
tuagenos septuagenta quadruor. Erogabat p̄ sumē quin
rias mille trecentos quadraginta octo. Amplius quī cō
tenarius conceptionis modū significat ūrum. quarius sexcen
tum nonē mum; quā recepī hucusq; usē nā possum; quarius
mille decē quatuor. Sūma q̄ī uerā cap̄ ī p̄sumē p̄ter
pisci ī cedebat. quarias duo milia septingentos nonaginta
octo. Q̄ errore ūsuetudinis ūcusi ūcare. mīs ī nouissē debeant
uēnire. Marciae Inō tenarius adscripsē modus quarias
rum decē milia centū octoginta quatuor. Adcap̄ ūtem
tuenginta quarius quadringentos octoginta quinque. amplius

quā icō memarius ē. quarios duob; milib; q̄ gigentos ſuigenti
ceo. Crogabant aūq̄ ad piſcinā q̄ uenirent. q̄ narienonagin
ginta q̄nq. dabant in uxorios ſepulc. q̄ narienonagin
due. Itē ante one q̄ narie centū ſexaginta quadruor. Sūmā
quę erogabāt aūpiſcinā q̄ narie trecente q̄ quinquaginta una. Mod;
q̄ piſcina ñ ſurrexit poſtq̄ ſunt. quę meo q̄ circa piſcine ductū
eo dē canalis arcuę recipt. efficit q̄ narios duo milia nonagin
quadraginta quadruor. Sūma q̄ ea uero erogat aūpiſcina aut
q̄ narios arcuo recipt. q̄ narioꝝ ura milia ducente nona
ginta q̄nq. Amplius quā ī cepti cō mtarios poſtq̄ ē. qui
narios mille centū trigintatres. Min; quā ñ ſuperedicapt
acre efficiunt q̄ narios mille trecentos nonaginta q̄nque.
Crogabat poſt piſcinā q̄ narios mille octingentos quadra
ginta. Min; quā icō mtarius ē ceptionis ſignificari dixim;.
q̄ narios ducentos ſuigenta ſeptē. Min; quā ex piſcina marcus
recepit. ſunt q̄ narie mille centū quadruor. Sūma aūp
que ī tercedebat aut ītercapt 7 piſcinā. aut p piſcinā
q̄ nariarū duo milia q̄ ngente. quę ſic ī ceteris pluribꝫ locis
ī tercipi dependim;. ñ enī eos ceſſare manifeſtū ē. 7 ex hoc
eo q̄ capt prīmi ñ ſurā quā cōpendij cauſa ſpectant ē ducti
poſtum; effundunt amplius trecente q̄ narie. Tepulę In 68
cō mtarius adſcriptus ē modus q̄ nariarū quadragintarū. h̄ius
aque ſomes. mulliſam. hiemſ q̄; dā ē ſtabat. que ī ter cepte ſunt
mulia. Capt ergo eius obſeruandū ē apiſcina ulie. q̄ nariū
primū accipt q̄ narios centū nonaginta. deīde ſtatim ex marca
q̄ narios nonaginta duos. Preterea exam one nouo. adhortoſep
phocrates. q̄ narios centū ſexaginta tres. ſunt omes q̄
narie quadrigente quadragintaq̄nq. Amplius quā ī cō mta
rius q̄ narios quadraginta q̄nq. que mero gat ne cōparent.
Julię Jncō mtarius aſcriptus ē modus q̄ nariarū ſexcen 69
tarū quadragintanouē. Adcapt ñ ſura inuriñ ponit quo
uas explurib; adgſtionib; ē ſtat ſet ſexti abarbenularū.
mulſa ī piſcinā recipt. ubi modus eius manifeſtus ñ ſuri efficit.
q̄ narios mille ducentos ſex. Amplius quā ī cō mtarius. q̄ narios
ſingentos ſeptuaginta ſeptē. Preterea accepit pprie urbē phoc
tos pallantianos exclaudia q̄ narios centū ſexaginta duos.
Eſt enī ī ulie acceptus q̄ narie mille trecente ſexaginta
octo. Exeodat intepulā q̄ narios centū nonaginta erogat
ſuo nomine octingentos tres. ſunt q̄ ſi erogat q̄ narie non
gente nonaginta tres. amplius quā ī cō mtarius habet q̄ narios
trecentos quadraginta quadruor. Min; quā ī piſcina habit
poſtum; ducentos decē tres; q̄ ſi ipſa ſapt eos q̄ ſtuchenes ſibi
primā piſ uſurpabam depenſim;. Virginus Jncō mta
rius aſcriptus ē modus q̄ nariarū ſexcentarū q̄ nquagin
ta duarū mus. Menſura ad capt ī uenire ī portū. q̄ ñ
explurib; adgſtionib; ē ſtat. 7 leny or riuo ītrat. ppe
urbē mīa ad miliarū ſeptimū ī agro q̄ ne eſt celony. cō moch.
q̄ mo locior ē ſan cur ū habet. mſura ē gi. q̄ narios cen qua
ginta duorū duo milia q̄ ngenta ſ quadruor. Amplius quā ī cō mta
rius q̄ narios mille trecentos q̄ nquagin. inbus ab;

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80 cantungaram ſ manerunt · quinquedecim · lacib; nongenta duo-
quinquedecem ſagmaſex · Anyonſ uetercſ erogabant ex eis
urbē nonaeceſarſ · quinquaginta nouē ſexagintanouē · pruinc ſ quinqua
ecccxcvii · Reliquę quinquaginta octo ſemſ · in urbē
dandebant pregiones ſeptimi · nonī · quintidecimi · in castella
xvii · xviii · in castella nongenta quinq; ex quib; nonnecesarſ
quinquaginta · Inſſingulis quinquaginta ecclxxx · priſcis qui
narie quingentaſ ex · Ex eo · Caſaris ſ quinquaginta equitibus
gintaopib; publicis ſ ex · quinquaginta ſ nongintaſex · in urbē nouē ·
quinquaginta octo · lacib; nongintaquinquaginta ·
81 centedecē ſ octo · Quinquedecim erogabant ex eis urbē nonaeceſarſ
quinquaginta ecclxxx · Reliquę quinquaginta nouē ſ quinqua
agintadue · in urbē dandebant pregiones ſeptimi · nonī · quintidecimi ·
xvii · xviii · in castella nongintaquinquaginta · ex quib;
nonnecesarſ quinquaginta ex · pruinc ſ quinquaginta octo ecclxxx ·
82 quinquaginta ecclxxx · Tercio erogabant ex eis urbē nonaeceſarſ quinqua
duum · pruinc ſ quinquaginta ſex · Reliquę quinquaginta
ecc lxxx · in urbē dandebant pregiones ſeptimi · nonī · quintidecimi ·
in castella xvii · ex quib; nonnecesarſ quinquaginta duum ·
pruinc ſ quinquaginta ecc lxxx · Quib; publicſ quinquaginta
83 ex · Ex eo · Caſaris ſ quinquaginta ecclxxx · quib; publicſ nouē · pruinc ſ sexa-
lacib; ccxcvii · quinquaginta ſex · Julia Augusta ex eis urbē nonaeceſarſ
quinquaginta ſex quinquaginta · pruinc ſ quinquaginta ex · Reliquę quinquaginta ecclxxx
quadraginta octo · In urbē dandebant pregiones ſeptimi · nonī · quintidecimi ·
decimi · xvii · in castella decē ſ ſeptē · ex quib; nonnecesarſ
quinquaginta octo · Quib; publicſ quinquaginta ecclxxxii · Ex eo
Caſaris quinquaginta ſ nongintaſex · quib; publicſ quinquaginta · pruinc ſ sexa-
quinquaginta ſ septē · lacib; ccxcvii octo · quinquaginta ſex · Ex
84 Virginis nonnullę ex eis urbē · quinquaginta · Reliqui
quinquaginta duo milia trecentaquadraginta · In urbē dandebant
pregiones ſeptimi · nonī · quintidecimi · in castella decē ſ octo ·
ex quib; nonnecesarſ quinquaginta nouē · Pruinc ſ quinquaginta
ecclxxxiii · Quib; publicſ octingentaſexaginta ſeptē · Ex eo
Quinquaginta quinquaginta · lacib; ccxcvii octo · quinquaginta
unū · quib; publicſ ſedecī · quinquaginta ecclxxx · In quib;
85 perſeuerauerunt ſi nonī decimi · quinquaginta ecccl · Alij
centenarie trecentaquinquaginta · hectara quinquaginta
ſ unū · nonnecesarſ quinquaginta ecccxcvii · quinquaginta
86 ſex · pruinc ſ quinquaginta octo · Claudia ſ ampe
nonnullę ex urbe · pro quib; pruinc erogabant · in urbem
ſ in dandebant · ſ alia quadraginta ex urbē nonaeceſarſ
quinquaginta ecclxxx · pruinc ſ quinquaginta ecclxxx nouē · Quin-
nonnullę nonnecesarſ quinquaginta ſeptingentaquinquaginta octo ·
reliquę ex eis quinquaginta quinquaginta quadraginta octo ·
quinquaginta octo · In urbē dandebant pregiones urbis ex ·
in castella quinquaginta octo · Ex quib; nonnecesarſ qua-
ginta octo quinquaginta octo · Ex quib; nonnecesarſ quinquaginta
septē · lacib; publicſ quinquaginta octo · Ex eo ex ſ nouē ·

quinq quadrantū . quarum sequentiq quoq modo diuisis quadra
tarū diametros singulos adiecimus singuq quadrantū
crescentiū differentias quadrantes diametrales habet . Sequ
tur ut serie . Deinceps in tabulis ceteris usq ad uicenariū . Omnū — 26
aūm modulus colligē duodenario . aut per ternarios . aut ere
sibus quibus capiet abstrahet . Differentiā uicenarii digitqu
drati . Digitorum dū significandi sic modo ponimus . Uten
dūē sibi nos in quinario . qui modulus ceteris omnibus maximus
cepē . Uicenario ergo modulus habet diametri digitorum .
Triangulo digitorum plus quinario eorum . hoc est sesquinoua
quinario . Scripulis . hoc est scripuli digiti quadrati rotundi .
reddē . habet diametri digitū unū . Digitis quinq sescuncia
capit quinario quadrati . Digiti rotundi habet diametri di
gitū unū . capit quinario scripula nouē . Octonario — 27
moduli quinario eorum . duobus genibus ceterorum accipiunt
quinario ipsa multiplicata . desit eōdē unum aut plures quinario
ibidem . igit secundū lectionē quinarii amplitudo
luminis crescit . Cū autē fuerit ibidē . aut plures quinarios
parare nemo suspicē nullet una fistula . quippe cū ca
pitelli . et quosingulos suis modis recipiunt . Alterum genus — 28
quinarii quinarios necessarie . fistulā ceterorū
capit . et addiametri sui nūm sedecim . et nō recipit
plus capacitatis aplius . Supra quinaria autē adiecta ceteris addu
metrū . quadrantes fistularum . nec tamen solidū capacitatē
aplius . capit enī quinarius unā . et quinq anc . et quinq anc
et dei cepsi ordinē ratione quadrantū et diametrorū adiecti
ut supdictū ē . crescunt septenarius octonarius nouenarius usq
ad uicenariū . Subsequit declaratio . quē sint numero — 29
digitq quadrantq quarenda desit lumine aut si modulū
ēmicē . agit et nō fistulae capitum . ut q̄ habet area
desit luminis circuli cuius digitos quadrantes ligumina
quinq uicenū signū appellat . Similiter uicenarius et de
ceps per ceteros digitos quadrantes usq ad centenū
uicenū . In uicenario fistula q̄ici mensuram quinq — 30
omnes restat est . ut q̄ ratione pene ē grauior . nā ibi est secun
dū cōputationē et precedentibus modulus est rotundus est .
ideo diametro quadrantes ligumina cū diametri eius decē digi
quinq sunt . et secundū nō modulū ratione ē sequitē adeo .
habet digitos quadrantes et quinq anc ligumina . Ratio — 31
fistulari quinarii usq ad centenū uicenū positos mo
dulos restat habet ut ostendimus . et nūm genus intrā se sibi .
Conuenit ceteris modulis quinarius ut in ceteris primus
primis principiis potest et est primus . Sunt aliq
nario sua uicenaria sequenda est . utroq cōmuni
modulis pulcra . Sed aliquando manifesta ratione
plurib et semper . in quadrato modulus nouenarius
duodenarius . et uicenarius . et centenarius . et centū
centū . et duodecim anguli . nec magnitudine . hæc — 32
ut sit frequentē . quasi diametro adiectum digitus semis
cū . sexq et capitum quinarius ebetē . Reliqui autē ibi

XVI

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apē aquarū habebat duumuiri quinq; capiebant quinquaginta
centū congiarios. ꝛc. quibus duarū centenariarū fuit.
Liber primus explicit. Liber secundus incipit.

64 Prosequē aḡ demodulis dicendū necessariū. nē pōdō quod modū
quoq; aquā primi pōnāt ēe pensū. usq; ad nūm cuiuslibet
ulasue. quarūq; erogatio. dei dequā plisq; ꝓpulsa īgressionē
fecere. prudentia opus mi diligentissimq; ne uos ꝓpositi in
urbē. Fuerē ḡ qui cōtenderūt sine modulis aquarū decēdua
milia spargenda esse quę quotā magna uel erogationis decē quidem
milia deesse. plus tñ hi in ratione equā acceptū. cōputabāt quarū
mille ducentis quinquaginta ribus. Ꝉ mus rei admirans eius ꝓpositū
officiosq; meo plorandas dēsq; quirū adq; capiā redimi. ñ mecha
nicē tñ nec ūtra adscriptiuorū. quā ad modū ꝑplus erogaret.
quā ꝓter immodo. aūt radicā esse. Ānecessariā itaq; capi modulorū
mensurā aggressus sū. ꝉ longe. ideo circūq; narus decē milibus am
plior. quā ī cō ūtra modū īuenī. ūpsingulas demonstrabo.

65. Appiae Ine ōnarius adscripē modus quarū ōnū ꝛc.
Limus tuus q; ad capē īuenit mēsurā ꝓtulit. qm quadrubus rus
ētur. Ad gemellos tñ ḡ locus ēt ꝓpē uetēm. ubi unum gē tū
ramo augustę. Tuę uale et ut dinā q; poles q; q. Iam ut dinā pedis
unus declarat. Fiunt ar cepoles octo. decimus centenarie
ungui due. ꝗ quadragenarię quę fiunt quarus mille octin
gentas ungui q; q. Amplius quā cō ūtrarius habet quarus trin
gentos octoginta quatuor. Erogabat quinarius ꝓpinguis
quadrus mus. quā cō ūtrarius adscribē. quarus centū
ginta ꝓpē. ꝗ ad huc mus. quā ad gemellos mēsurare ꝓpondet
quarus mille centū ungui. mua fiēdi. tñ alia quę mā adhuc
untio. quā sit dēpditio. ñ facile manifestone ostendat. quas
ersę quo adparet q; ī plerisq; urbis partib; ꝓbata aqua deficere
dā q; ꝓmanat. Set ꝗ quasdā fistulas ī ūtrarius ī ueni defen
dim. Ceterū urbē ꝓpter hoc ūra libere quā sit mis. Ceterū ad
66 adscriptiuos ḡ quinquagena. nulla acceptura. Ānuo uncia ī
Adscribit ēt cōtrarius modus quarū ūq; mille quadringentarū
quadraginta unus. Ad capē tuę quadrantes mihi mensuras
nem quinquaginta octo. ꝓtq; modū q; ꝓpter ī ūchuū tubi ī ūdere mē.
Amplius quā ī cō ūtrarius est quarus duobus modis, octingentis
quinquaginta ī ūpē. Erogandū aliquā ad piscinā ūtrarius ut qui
narus ducentes ī quinquaginta ī ue. Modus ampli quinquā fuerus
postmodū. efficiat. quinquarū duorum milia ut ēt quinquagin
duas. Inter ea debant. ergo ī ūtrā ꝓ piscinā quinquagin
tingentes septuaginta quadruor. Erogabat ꝓpiscinā quin
rias mille trecentas quadraginta octo. Amplius quā ī cō
ūtrarius concepti modū significari dyum. quarus ligne
gurantonē mus, quā recepti chuorū ꝗ ulei. nō pessimus, quarus
mille decē quadruor. Sūma q; inter cā ꝗ piscinā ꝗ pter
piscinā ī ūcedebat. quarus duo milia septingentę nonaginta
octo. q; errore mēsurā ūtrarius ostenderat. mihi ī uestigatione
cendi. Marciae Ine ōnarius adscripse modus
rum duorum ūtrarius quinquaginta duorum. Ad capē ūtrarius
ī uenio quarus quadringentas mille septingentas quinquagin. amplius

quā icō mēsurā sē. qnarū siduob; milib; qngentis qngnagīta
cto. Erogabant aūqūad piscinā ꝑuenirēt. qnariā nonagīta
gīta qnq. 7 dabant inde uxorib; ꝑpulie. qnariā nonagīta
due. Itē unyonē qnarie centū sexaginta quadruor. Sūmā
quā erogabāt ānpiscinā qnariā trecentē qnquagīta una. Mod;
qnpiscina mēsurā posat; mīt. quomodo q; circa piscinē eductū
ecclēcanalis marcuq; capit. efficit qnarias duo milia. nongenta
quadragīta quatuor. Sūma quā uero erogāt ānpiscinā aut
qnarias arcuo recipit. qnariā ūna milia ducenta nona
gīta qnq. Amplius quā icēpti cō mīsarios posttū. qu
narias mille centū trigīta tribz. Min; quā mēsura educapit
acte efficiūt qnarias mille trecentis nonagīta qnque.
Erogabat post piscinā qnarias mille octingenta quadra
guīta. Min; quā icō mīsarius cēpti nomīs significari dyrim;.
qnarius ducentis uigīta septē. Min; quā ex piscina marcus
recipiūt. sunt qnarie mille centū quadruor. Sūma autē
que itercedebat aut itet capit 7 piscinā. aut ꝑ piscinā
qnariarū duo milia qngente. quas sicūt icteris pluribz locis
itercipi dependim;. nēmeos cessare manifestū. 7 exhoc
eo g capit ꝑmīmēsurā quā cōpendiosē capiūt eductus
posum; et fundum amplius trecente qnarie. Tepulie In 68
cō mīsarius adscriptus ē modus qnariarū quadragīta. humus
aque fontes. nullus iam hemis qbz dā ē simbat. quelter cepte sunt
mulia. Capit ergo eius obseruandū ē apiscina ulie. exterēs
primū accipit qnarias centū nonagīta. deīde sitim ex marca
qnarias nonagīta duas. Preā examone nouo. adhortos ep
phos duanos. qnarias centū sexaginta tres. sunt omēs q
narie quadrugente quadragīta qnq. Amplius quā icō mīsa
rius qnarias quadragīta qnq. quemero gnt nec cōparent
Juliue Incō mīsarius scribtus ē modus q nariarū sexcen 69
tarū quadragīta nouē. Adcapit mēsura inuri ponit quo
uā explurib; adgstionib; ē stat set sexā abur bemiliarū.
iumēta ī piscinā recipit. ubi modus eius manifestis mēsuris efficit.
qnarias mille ducentas sex. Amplius quā icō mīsarius. qnarias
quingentas qnquagīta septē. Preterea accepi ꝑ urbē ꝑhor
tos pullamanos exclaudia qnarias centū sexaginta duas.
Est amēnulie mace ptus qnarie mille trecente sexaginta
nouē. Erodat in topulā qnarias centū nonagīta erogat
sue nomine octingentas tres. sunt quas erogat qnarie non
gente nonagīta tres. Amplius quā icō mīsarius habet qnarias
trecentas quadragīta quatuor. Min; quā i piscina bāt
posum; ducentis decē tribz; quas ipsas apē os q sue heneficiū
primacpis usurpabam defensim;. Virginus Incō mīsa 11
rius scribtus est modus qnariarū sexcentarū qnquagīta
duarū manus. Mensura adcapit iuenire ponit. qui
Oplurib; adgstionib; ē stat. 7 leuyor minuo itrat. ppe
urbē mīa ad miliarū septimū magro; nicetis celom. cō moch.
ubi locior est eurū habet. mīsurā egi. qui sicut quin
quarū duo milia qngentas quadruor. Amplius quā icō mīsa
rius qnarias mille trecentas qnquagīta. inbus abs

bationem ex predicta summa. Erogat enim omnes quas mensura deprehendimus, id est duo milia quingentas quadraginta. Alsietinae Con-
71 ceptionis modus nec in commentariis adscriptus est, nec in rerum scriptis certo invenire potuimus. Cum ex lacu Alsietino et de incertis caricis ex balneis quantum aquarum tempe[illegible] Alsietina erogat qui-
72 narias trecentas nonaginta duas. Claudia Abundantior aliis, maxime in tarie exposita est. In commentariis habet ut plus quinariis duobus milibus octingentis quinquaginta quinque. Cum ad caput invenimus quinariorum quadraginta milia sexcenta septem. Amplius quam commentariis mille septingentis quinquaginta duabus. Ad eam nostrorum est mensura, ut ad septimum ab urbe miliarium in piscina ubi incertae mensuras sunt invenimus quinarias triamilia trecenta decem duas. Plus quam in commentariis quadringentis quinquaginta septem. Quamvis et ex beneficiis ante piscinam eroget, et plurimum subtrahi ideo pendimus. Ideoque minus invenimus quam revera esse debeat. Quinaris mille ducentis nonaginta quinque. Et circa erogationem eius fraus apparet, quae neque ad commentariorum fidem, neque ad eas quas ad caput egimus mensuras, neque ad illas alteras ad piscinas pro tot iuriis sunt convenit. Sola enim quinaria mille septingentae quinquaginta erogantur. Minus quam commentariorum ratio dat quinaris mille centum quinque. Minus autem quam mensura ad caput facta demonstravimus quinaris duobus milibus octingentis quinquaginta septem. Minus etiam quam in piscina invenimus quinaris mille quingentis sexaginta duobus. Ideoque cum in cera in urbem propriorum pervenisset in urbem usque cum antiquo nomine, ut deffusione facta et conceptione earum et erogatione esset obscurior.

Quod si quis fortasse ad quaestionem mensuris blandiri putavit, admonendi sunt ad eorum et cerulorum fontes aquae Claudiae sufficere ad praestandas ductui suo quinarias quas significavimus, quadraginta milia sexcenta septem, ad praestandam mille sexcentae fundatae. Nec eo iniciatis quin eaque superfluunt, non sint propriae horum fontium, cum in eorum [illegible] quae invenimus in arcis sub plenitudinem illam indigere. Ad eque in fontibus Claudiae quae invenimus nec huius quidem deductionem aquam recipiat. Anio novus In commentariis habet ponebat quinarias triamilia ducentas sexaginta tres. Mensus ad caput reperimus quinarias quadraginta milia septingentas triginta octo. Amplius quam in conceptis commentariorum est. Quinaris mille quadringentis septuaginta quinque. Quarum ad quaestionem nihil aut de meam plenitudinem quo alio modo [illegible] quam quod erogationem ipsorum commentariorum maior pars earum [illegible] quinariarum quadraginta milia ducentas [illegible] in commentariis [illegible] conceptio. Nam amplius quam [illegible] milia [illegible] sexaginta [illegible] intercepta [illegible] quingentas viginti septem. Quae [illegible] erogationem [illegible] longe amplior modus [illegible] ut ex largo et celeri fluvio [illegible] modum.

74 Non dubito aliquos admonitos [illegible] longe maior copia [illegible] mensuris invenisse quam erat in commentariis principio. Cuius rei causa est error eorum qui [illegible] diligentiam [illegible] aestimationem [illegible] [illegible] mensuris [illegible] [illegible] Quae cum [illegible] est causa quae [illegible]

aliquid ꝙ de regni decē milia marcarū ei ecclesie. Beneficia suppressa
secūm modū cōmunis utilitatis. Sequenti ordine cōgruus
modus conquirat adcapta. Alius nec exiguam nec
desidie distributionē timet. cuius pecunia est fraus. quam quis
aliquis ex ducatu publico. primatus ipse destruat reddendus.
Sedes pene proposite. et quia agonis quam ei duce unde. formas
videat primatus. nisi ne aliquid de re publica hominibus primatus. uel
alienari nūs suspendat. de diuitiis. de pecunia nec 76
melius aliquis. quē ecclesie ordo pecuniam. cum nō
ullus est usus. quem nos ecclesiasticum ingenium. cum nō
possemus habere. in quos agros. uberes ecclesie cenaculum. corrup
tibus clericis quos pene missales uiros inuenimus. Nā si alius
nouus ecclesie ius ac ero gabunt. et si ille uetera ceteris summa.
Interea quo mō dationē debant exigē. iumenta mō. q
ferre cum amonte celū. aut omnimō accidit. Qui colles prius quā
claudia ducēt. urbanē martyr ulla. Sed post quā neros
pater claudia operuerunt. sed exceptus quadrāplū dunda
dispdixē ndi dedisti buere. prospes iam piare. si omisse sum.
anullam ecclesiam. si de usus est. quos quidus mutata
aqua uel appellatio mutat. Sanis ādem modo cuius p. uelut 77
nouaquidā adgestione. quibus si audibus. unus quecumque
dicti est. sup est uderogatiuo nequi ferā. iudicē dicā unmassā
tuenum. minore tā falsis nominib. posita p. nominū aquarū.
unusquisque habet. pregones urbis digeram. Cuius cōpensio.
nescio ne tenuitatis. si et ā plena uideri posse. ponem. tamquā
breuissime. nequid ludi formule officii distractus sufficiat. cognō 78
uisse sūmā lucebit transire lenior. Uidergo distributo quinari
arū quadruor decī milia decē. occo. nta. quadrāgenarigenta
sex. quinq; que ex quibus dīa quisinad uxori usū aluarū dare.
ubi inspecie ero gationis cadunt. semel cō putationē nemini.
Ex his diuidunt ex urbē quinarie quadruor milia quingenarie ses.
Ex q. b. nomine cesaris quinarie mille septingente decē. occo. primus
quinarie ooo. ccc. xxxvi. reliq; in urbē milia nongente quinqua
ginta quinq; distribuebantur in castella ducena quadraginta sep tē.
q. ero gabant sub nomine cesaris. quinarie mille septingente
septē semis. Primus quinarie trium milia octingente quadragin ta
septē. Isib. publici quinarie quadruor mille quadrāgenarie
una. Exco Castris ducen marie. ducen a septuagina nouē.
q. rib. publicis septuagina quinq. quarie ooo. ccc. minor.
rigina nouē. quinarie ccc. xxvi. Iacob. q. ginte nonagina mum.
quinarie oo trecenta uigintuq. Set si. ripsi dispensatio. no
mina aquarū pregones urbis parendae. Ex quinarius ergo quid 79
quordecī milib. decē occo. quas sumi erogationib. omnib. uisse
posuim. Dant nomine ergo urbē. quarie tam amodo q. q.
quo mā humilior ut sta. minorib. reliq; quarie ecclesie nona
ginta nouē. In urbē duodecim pregones ecclesie. Iacob. xi
xii. xiii. xiiii. Castella uiginti. Ex q. b. nomine cesaris quinarie
centū q. quinquaginta unū. primus quinarie centū nonaginta quad
ruor. publici quarie trecenta quinquaginta quadruor. Exco
Castris. quinarie quadruor. [illegible] publicus quadruor ducenta. quarie

centum quinquaginta tres. muneribus novem. quinariae duo. lacibus nonaginta duo
80 quinariae ducentae sexaginta sex. Anyonis veteris erogabantur extra
urbem nomine Caesaris quinariae centum sexaginta novem. privatis quinariae
CCCCIIII. Reliquae quinariae mille quingentae octo semis. intra urbem
dividebantur per regiones primam. III. IIII. V. VI. VII. VIII. VIIII.
XII. XIIII. in castella triginta quinque. Ex quibus nomine Caesaris
quinariae sexaginta. In usus privatorum quinariae CCCCXC. publicis qui-
nariae quingentas tres. Ex eo Castris unum quinariae quinqua-
ginta. operibus publicis XIX. quinariae centum nonaginta sex. muneribus novem.
quinariae octoginta octo. lacibus nonaginta quattuor. quinariae du-
81 centae decem et octo. Marciae erogabantur extra urbem nomine Caesaris
quinariae CCLXIX. Reliquae quinariae mille quadringentae septua-
ginta duae. intra urbem dividebantur per regiones primam. tertiam. quartam.
V. VI. VII. VIII. VIIII. XIIII. in castella quinquaginta unum. Ex quibus
nomine Caesaris quinariae CXVI. privatis quinariae quingentae quadra-
ginta tres. castris IIII. quinariis XLI. in operibus publicis quindecim.
quinariae XLI. muneribus XII. quinariae CIIII. lacibus CXIII. quinariae
82 CCLVI. Tepulae erogabantur extra urbem nomine Caesaris quinariae
LVIII. privatis quinariae quinquaginta sex. Reliquae quinariae
CCCXXXI. intra urbem dividebantur per regiones quartam. V. VI. VII.
in castella XIIII. ex quibus nomine Caesaris quinariae XXXIIII.
privatis quinariae CCXLVII. usibus publicis quinariae quinquaginta.
83 Ex eo Castris I. quinariae duodecim. operibus publicis III. quinariae septem.
lacibus XIII. quinariae XXXII. Iuliae fluebant extra urbem nomine Caesaris
quinariae LXXXV. privatis quinariae CXXI. Reliquae quinariae quingentae
quadraginta octo. Intra urbem dividebantur per regiones secundam. V.
VI. VIII. X. XII. in castella decem et septem. ex quibus nomine Caesaris
quinariae decem et octo. usibus publicis quinariae CCCLXXXIII. Ex eo
Castris quinariae sexaginta novem. operibus publicis quinariae CXXXI. muneribus
quinariae sexaginta septem. lacibus viginti octo. quinariae sexaginta quinque.
84 Virginis nomine exibant extra urbem quinariae ducentae. Reliquae
quinariae duo milia trecentae quattuor. Intra urbem dividebantur
per regiones septimam. nonam. quartamdecimam. in castella decem et octo.
ex quibus nomine Caesaris quinariae quingentae novem. Privatis quinariae
CCCXXXVIII. usibus publicis mille centum sexaginta septem. Ex eo
Muneribus II. quinariae XXVI. lacibus viginti quinque. quinariae quinquaginta
unam. operibus publicis sedecim. quinariae mille CCCLXXX. In quibus
85 per se Euripo cui ipsa nomen dedit. quinariae CCCCLX. Alsy-
etinae quinariae trecentae nonaginta duo. Haec tota extra urbem
consumitur. nomine Caesaris quinariae trecentae quinquaginta
86 quattuor. privatis quinariae centum triginta octo. Claudia et Anyo
novus extra urbem proprio quaeque rivo erogabantur. intra urbem
confundebantur. et Claudia quidem extra urbem dabat nomine Caesaris
quinariae CCXLVI. privatis quinariae CCCCXXXVIIII. Anyo
novus nomine Caesaris quinariae septingentae viginti octo.
reliquae utriusque quinariae tria milia quadringentae nona-
ginta octo. Intra urbem dividebantur per regiones urbis XIIII.
in castella nonaginta duo. Ex quibus nomine Caesaris quina-
riae octingentae viginti. privatis quinariae mille sexaginta
septem. usibus publicis quinariae MXII. Ex eo castris novem.

quinquiecentū quadragintatrium ꝯ aplis publicis decē ꝛ octo. qui
uirie ccc lxxx m. mutuis xx. quinquiecentūsepte. lacubi centū
uiginti sex. quinquie ccc xx. ꝛ cl. hec ornamenta. adneruū 87
imperatore usq; cōtinua. sed hunc modū deseruebat. nē prudentissima
diligentissimi principis que quotidie fruebatur aquarū copia
putaret. aut merito putaretur. quasi nouā uetustate formā adeuntis
aque publica uberta sileret. nō sedulo deinde principe diligentia.
aut pretio ambitiosi quibus singule seruiebant aque plures esse uerē.
nūquā cessatio ꝛ auctoritate quosdā latrones parcius ne romanos
ducebat. quos fieri ludi quotiens deprehensos aliquos inuenisset.
celeberrime celebrasset. quibus nec plures esse aque. ꝛ premissi
marcia redisse. amplo operis monumentū usq; ducē. adque
eas omnes partes urbis lacus tā nouus quā uetus. plerique mensē
lemures dū sarta aquarū accepum. nisi casus diuersum tam 88
pedisset. Alterna sufficiente dein de seruare usus. Genius nunc
curam imperii spiritum uere principis sui regna ꝛ numina
orbis ille. q; tranquilla ēsse. cui pro nihil ꝛ nichil ille dem.
ꝛ magis semper salubres esse eius dē et urbis. auctoritatis et ꝛ.
opum. munerū. ꝛ lacuū numero. Nec unum ad primos cōmo
dā peruenisse. neq; eius diffundi. aliquoq; ut multis
ex aqui ducebant. sed ne ex beneficiis inuenitur. Hi per uos
quidē aqueductus sunt. alia munda aquarū facies. puriores spiritus.
per eos gustus fecti. quibus apte uetustis urbis fames facer fuit. est
remotus. Hanc tū me deberi opinetur erogationis ordinationē.
ꝛ hec tū ita eueniret ad nostra tempora. ꝛ religiose rectē ponenda. 89
nisi consuetudo fuerunt. Quid g; nec hoc diligentissimi principis
quā maxime cuncta sint plena. sufficiat parū prudenter uolupta
tibus seruisse. sed ea redemisse. quā uitiosa copia adhibere. nisi ea plasm
ea uere nō cuncta re quā. Operā ē ut pinguia. que
alicubi occurrendo. unius quorundā uitiis adhuc uidentur.
ꝛ alibi quando cura sit. cū ut exiguum breue est apparentium.
si turbulenta limosis q; quos habuit. nec q. nec unum usus. do
mine nō rarum ē. aut quā structi cōmodius emendare debuit. q
capium ex fontibus. Imprimis marcia ꝛ claudia ac reliquę
quarū splendor ac capacitas roget mihi aut minutū plurima
quinque. si pura ex rupe ꝛ abiecta sint. Duo rectissimum 90
primum. limpide. nā sumum ex flumine. ac sepe rena si no
ebant. quoniam quidem purissimo defluent lacu nobili
tamen celeritatis rapidissimo aufert aliquid quorbet. primusq;
eleuemur Imus. Quod cō modū nō solū hyberni ac ūnis.
ꝛ etiā estiui umbrosi sunt. quo tempore ex eis grauior aqua
rū sincerea. Exigit ꝛ alter quidē ꝛ hic. adest amnis uenus. 91
cū pleriq; libras xx. inferior. cō modū ex ea ceteri. Hauit
alia nyo. utrabat ceteras. nisi diuissimus uenia. ꝛ pri
mus habundans. defectio natura rū fuit cursus. Imprimis aqua
rios deducentū. malueno se eis peculi requem nisi qui ex
pleno oriens. eras sufficiente aqua. quibus. maxime
claudia. quę multarum ruinas passus propria uetustate ne-
demū diuy ne permissa. multo extemplo debat. proxime.
adeoq; obuenientibus illi succurrebat. ut plerique ex
septem principum. nunc dignū erat aquas fur

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7 pompeius longus ē sulos. en. dopmenus [illegible] fer. afro nerone
claudio cesare. iiii. 7 cosso cesti. f. consulibꝫ. l. pisone.
ūgnio rufo. 7 mēmio regulo ē sulibꝫ. petronius turpilianus.
turpiliano gallo fragi. 7 laecānio basso consulibꝫ. p. mamil.
mariolucus celesti. 7 suetonius paulinus ē sules. sunt eius
agryppa. agryppe filio. 7 galerio trachalo cos. albus
crispus. crispo uel passienus. iii. 7 cetera ne rui sule. pom
peius siluanus. siluano galerio messalino ē sulibꝫ. rāpius fla
uianus. flauiano uel pastiano. V. nro. iii. consulibꝫ. acylius
aviola. postquē imperator nemia. ōn. 7 ū gnio rufo. ē sulibꝫ.
103 ad nos curatores aquarū esse. Nunc q̄ obseruare curator
aquarū debet. 7 lege. senatus q̄ consulto ad ministrandū
actū primo ius subiungā. Curator aquarū ducende atque
x ītrahende aquas obseruandas iuris. ne quis ne ue cesaris. ne de
ne quis aquā publicā ūi imperatā. 7 ne quis amplius quā un pe
rauit ducat.] Haec ūi efficient ad modus quē ad quemq; ex
possit ad nouos salientes. 7 ad nouos beneficia principis pertinē
] mero q; ālia magnadura. multa plicio pponenda fraudi esse solli
citos. sub ūde ductus extra urbē arcendi. Adrecogno
scendas beneficia ūdem castelli. 7 salientibꝫ publicis faciendi
ad ministrationē missionē diebꝫ aquas fluit. q̄ senatus quoq;
104 ē sulto sacē iussit. uetuitq; ne quis hortos. Cuius
rubero. paulus fabius maximus ē sul. xi. f. denumero publi
cos salientū quos inuenerē. ita ne aqe ductus ue ē iuncta
quos. a7. agryppa fecisset. Q. f. p. D. E. P. 7 C. tunc
augū placere nec munus publicas salientū. quos nunc ē
tendi ē. ingēs negotiū ā senatu est impetrū. ad ispicā
] aquas publicas. uiri ent q; numerū salientū publicas.
rēq; placē aurato. et aquarū quas. S. C. cesa nouiq; stat
ex senatus auctoritate nominant. Dare opā ne ui salientes
publicis quā ad siduissime ītercludꝫ nocu. aquā ne ui
poss fundent.] n̄ho senatus ē sulto ne quis der madmodū
ā. gsenatus cā augeri quā minus ne ui salientū publicoꝝ numerū
uetuerit. ne ue facta ex ea sit minus. q; modus aquarū quel. ī rēpo
rib; inscribē uenebant. Antequi claudius 7 anyo nouus pōtifex
105 maior ē ex gressione capere ne ui debant. Q; uis aquā ne ui ius
priuatos deducē uoleb. impetre ne uicichebā. 7 apprincipe ea
ad curatorē ad ferre. curator de ne uicle beneficia cesaris ī ire
menū narē. 7 per curatorē ē ne ui de ollion liberū ē cesaris
primi scribe. Procuratorē aquarū primus ne ui claudius inde
admonuisse. post quā anyonē nouū 7 claudiā idiyē. Quid
ē nim ne cessarium est aulici. fieriq; nō ne ui debeat. ne quando ne gle
gentia aut fraude ius. ignoramne colonie referendam ne
p rocuratorē calicē eius modulique fuerit imperatū. Adhibe ne
ministrorū. 7. signatorē cognitor. diligēt intendat in iurias
quas sup dictum modū? possimus. Nouū habebat, nec ne ui ma
iorē lubricatū. ītra ūi maiores ne ui mus. ītercidū in mori.
7 gīn ē sonū ē calicē habere. 7 nec fortuitū abhoc uberū fu
turendi quale cū ē plūbeū fistulā ē modū. ambitū ne ui

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quę ex ĕ ceruisi. aut uetus mox corrūpat. aut quid ipsum impediat.
aut ut ĕ pestifer. aũ culpa malefactoꝝ. q̃ sępius accidit. Jrecen
tibꝫ fere annis uetustate. aut ruina uel deductu aquarũ labarant. quarũ 121
arcubꝫ sublatis. aut montibꝫ cauatis. applicatę sunt. q̃ arcuatis
cubꝫ aquę possint ĕ cursus. ideoq; hęc opa sallucina festinatione
ex placitis facta sunt. Q̃m; in ruinis subiacent subĕrranea. nec quic
quid nec a calore. exposita. Viriaq; eius modi sunt. q̃ aut ñ ui
ꝫpellato cursu uenant ĕ. aut emendari nisi aũ fundi possint sic ut
dispar ipsa alueos facere necesse ĕ. Hęc duplici ex causa facta sunt. aut 122
emergente crescente quidem in crustã indurescit. atq; cor rupt.
aũt rectoria corrũpunt. unde fiunt manationes. quibꝫ ne
cessario uasa rumpuntur. ꝫ substructiones uitiantur. Pilę q̃q; ipse
ro so extructę. subtã magno oĕ labuntur. Reficiq; quę circa
alueos sunt. multi. et ea cedere debent. ne ĭ terminatur usus.
tẽpore quo pcipue desidat. Sz uere. ut autũno. ꝫ maxima aũ
festinatione. ut sulcet aũ ꝑparetis omnibꝫ. quę pinguissimis diebꝫ.
minus cessent. Hemmę fugit ꝑ singulos ductus hoc cẽ faciendũ. nec si
pluresꝑ uarie aũtumentur. desit aqua cuntari. Cum q̃ ĭ ꝑpetuo 123
aq̃ cursu esse faciendi debent. maxime structuram ĕ sanct. quę ꝫ suis
temporibꝫ. ꝫ fidelĕ fieri oportet. Jdoneũ structure tẽpus ĕ.
a calendis aprilibꝫ. ĭ calendas nouembres. ita ũ opus mũ sit ĭ ter
mini. nec ea pars ĕ structa. q̃ nimis caloribꝫ ĭ candescit. quia
tẽpus nocendi op; ĕ. ut ex eo mox structura cohibeat. ꝫ unum
ne ĕ crebet. Non min; aũ solacior quę ĕ celeriter ꝑficit. multũ im
nec ullũ op; diligentior ĕ possit cura. quę q̃q; eque obseruanda ĕ.
Fides itaq; eius singula. secundũ legẽ. notasq; omnibꝫ. ꝫ quas ciuis ob
seruandas ĕ exigendus ĕ. Jllud nulli dubiũ ĕ cor rectis ductibꝫ pximos 124
ductus. ideo ĕ quia ex omni ariola pide quadrato ĕ structum.
maxime eos rodendos. quę ĕ aptissimo possunt. ꝫ plures. quasi in
glutinatum ĕ. quos ĭ nouos ĕ fuerint ĭ ruptos. maior ĕ pars ea quarũ
urbs destituet. Remedia nata sunt. ꝫ humus difficultatibꝫ. Jncho
atq; exempli gratia ad libram deficientes. Aliquando uasa plumbea canalibꝫ ꝑ spatia
ĭ ruptos ducit. rursus communit. Porro q̃q; fere omnes ĕ ꝑ cur
primum ꝫ agros deriuationes erant. ꝫ difficulter uidebat futurum impensę
ꝑparationis aliquando ĕ structionę succurrere. ĕ simul. ne accessu
ad reficiendos primos redĕptores ꝫ possessoribꝫ prohibent. S. C. fac
tũ ĕ q̃ subiecta. q̃ q̃ aeluus rubera paulus fabius maximus ĕ cul. 125
u. f. dernus ĕ pecubꝫ. fornicibꝫ. que ulis. marcia. appia.
tepula. anyenis reficiundis. Q. D. E. R. F. P. D. E. R. I. C.
uiam uiam. fornices quos augustus cesar reficiendos curauit impensis
a sollicitus sit ne tuę reficiẽtur. Exagris priuatoꝝ.
ĭtra. limũ. lapidẽ. resta. harenã. ligna. cetaq; quibꝫ ad ea re
op; ĕt. unusquisq; ꝓxime. sine iuria ꝓ priuatoꝝ tollit. sumi
portari possint. iuria arbitratu. ĕ estimata. darent. tollere
rent. sumẽt. exportarent. ꝫ ad eas res omnes exercendas
das. earũq; rerũ ĕ ficiendarũ causa. quotiens op; ĕ. ĭ per
agros priuatoꝝ. sine iuria. eoq; itinĕ. actus. patet. da
rent. Plerũq; aũ uitia orta ex ĭ potentia possessoꝝ. quibus 126
ribꝫ riui solent. Primũ ĕ si parũ q̃ circa ductus aquarũ.
ex S. C. uacare debent. nũ edificia. aut arboribꝫ occupent.
arbores magis nocent. quarũ radicibꝫ. ꝫ cacumina manet. ꝫ lata

solum. Deriuicales uias agrestes q̄ priuatorum usui derigunt
nouissimo usui seruire placuit. q̄nia S.C. q̄ subrici
127 pulsum. q̄ q̄ lustri uberos paulus fabius maximus cōsul. iii. f.
aquarū q̄ in urbē uenirent. nimia occupari. monumenta q̄ edifi
cia q̄ arborib⁹ cōsep. que. f. p. d. e. r. i. c. cū adiacentibus
riuos specus q̄ pp̄ q̄ opa publicarū impune. placeret cōsumi
q̄ fornices q̄ muros ductuq̄ expone. c. unos clenos pedes
pte. q̄ per arcuatos q̄ subterranea ēēt. q̄ ne q̄ in urbē q̄ extra
urbē cōmenta edificia. nēq̄ exper. q̄ unos pedes fundos
relinq̄. ita ut neq̄ monumentū uim loci. neq̄ edificia possit hoc
cōp̄ ponē. neq̄ cōsep̄ arbores ducēt. Si q̄ ne cēnt arbores
it idq̄ parū excaperā. p̄terq̄ si q̄ ne ullē cōmenta q̄ mi
duse edificia cēnt. Si quis ad hāc rem cōmisisset. q̄ singulas
res pena hēs denarium cēnt. ergo q̄ pars dimidia. p̄mo
accusatori daret. cuius opa maxime cōmissum cēt. Qui
ad hāc rem hoc S.C. cōmisisset. pars dimidia. in erario
redigēt. digna rem iudicarem cognoscēnq̄ curatores aquārū.
128 Posset hoc S.C. equissimū uideri eum extremum publice
utilitatis. ea parcimonia durare. multo magis. cū maiores
mīa admirabilia equarūt. neq̄ q̄ dēripuerē. p̄ruerēt.
q̄ admodū publicis p̄ranebant. q̄ cū aquas p̄ducerēt. si dissi
cilior possessor in p̄tercundo fuerat. p̄ro agro
pecuniā irrulerunt. q̄ post determinauerē necessaria loca.
rursus eū agrū uendundi mō. ut in sumb⁹ p̄ri⁹ usus p̄s
p. quā priuata habent. Plerique autē in cētri occupassent
fines. ipsi ductib⁹ manu adiuuere. p̄ fructos alueos passim
cursus aquarū in perenne habent. quibus quoniā
cui beneficii occasionis ad expugnandos nūc ne cuiquā
quid possit fieri. summis uiis ad diligentissimā legē obti
nent. Per aquā mediocris crimina ab⁹ inc̄ remper. quae
129 subscripsi ubi legis. C. quintii crispini cōsul
populum uocauit. populusq̄ uocatus in foro proximo
aedis diuūm iulii. p. q. ministris seruis p̄ncipū fuere
p̄ribus. sex. I. f. iurro. Quicū q̄ post hanc legē rogā
tionē. specus. formices. fistulas. tubulos. castella. lacus
aquarū publicarū q̄ aduersus ēducere. sc̄ dolomata
formīū. pūpe. fornicis. p̄ipen inuerendi. pecuniā
fecerit. quam cuiusq̄ ea q̄ ue q̄ equa inuēta erit
ut ea. fiat p̄ncipis dari q̄ uenire. q̄ ea pecunia
ut loca. q̄ loca q̄ ea. dominus
possessoribus. li. f. aquaductus. adscribitur. ut ea
salua. distribuant. diuidant in castella. lacus. q̄ ad
ut populo ro. nunc centumuiratui reddāt. sed eo. q̄ quis
eo⁹ impedierit. adhibēsarcire. reficere. restituere. ae
dificare. p̄ficere. celare. dolare. dimittere. q̄ ne quis in eo lacu
aquae minuatur. p̄ficiq̄ curator aquarū. erit. sicu
rator aquarū nemo erit. tubi p̄ror quis ter cuius
pegnus ius dicio. imperio. pignoribus. cogito exercito
q̄ quis mortuus. aut sicarius. erit. nisi p̄ro eo. q̄ non
cogē. Decem cendi. ut adiudicandi sunt. pignoris capien

[illegible] quae est. Si quid eorum seruus fecerit. dominus eius
[illegible] nulla post locet. Si quis circa piuos. specus. fornices. fistulas. tubulos. castella. lacus aquarum publicarum que
[illegible] terminatus fuerit. neque eius
[illegible] hanc legem rogatam quid. obponit. molit. obsepit.
[illegible] ponit. [illegible] serit. neue meum quid
[illegible] praeterquam eorum faciendarum reponendarum causa
[illegible] hac lege licebit. oportebit quia [illegible] fecerit
[illegible] publicam [illegible] causa quod omnium rerum omnibus que
[illegible] oportere. sus [illegible] hanc legem riuum
specum rupisset. foras [illegible] quominus in eo loco pascere herbam.
[illegible] secare. sentes. Curatores aquarum qui non
sunt. circa fontes quae erunt. et fortuna et murorum. et riuos
et specus terminatus est arbores. uites sue praesentes ripe. ma
ceria. sallicta. harundineta. tollantur. excidantur. effodi
antur. excodicentur. uti quod rectum factum esse uolet. eo nomine
[illegible] capto [illegible] edicipo. o R. citi quesito id quod iussi me
fraude sua facere licet. Ius potestas quod iste. quominus
[illegible] arbores quae uillis edificiis macerie sue inclusae sunt. macerie
[illegible] aquarum causa cognita ne demolirentur dominis
[illegible] quibus [illegible] ipsorum qui permisissent cura
[illegible] nomina maneant. hac lege nihilum rogatio quominus ex iis
fontibus. riuis. specibus. fornicibus. aquam sumere aurire usque
[illegible] aquarum permiserit. permiserint. praeterquam rota calice
machina [illegible] neque foramen nouum fiat eius hac
lege nihilum rogato. Utilissime legis contemptores non negauerim
dignos pena quae intenditur. sed neque legentia longi temporis decep
tos leniter reuocari oportuit. Itaque sedulo laborauimus
ut quanta in nobis fuit etiam ignorarentur qui errauerant. Is uero
aut admonitio ad indulgentiam imperatoris decucurrerit. possumus
iudicari causam impetrati beneficii fuisse. In reliquo uero opto. ne
executio legis necessaria sit. cum officii fidem omnia per offensas tueri
praestitit.

130

Capitolium dictum quod hic cum foderentur fundamenta edis iouis. caput
humanum dicitur inuentum. hinc mons ante tarpeius diolum a uirgine
uenerat tarpeia. quo ibi a sauinis necata armis. uenerat et
sepulta. cuius nominis monumentum reliquum. quod etiam nunc eius rupes
tarpeium appellatur saxum. hunc ante montem saturnium appe
llatum prodiderunt. et ab eo late saturnia terra. ut etiam ennius appellat.
Antiquum oppidum in hac fuisse saturnia scribitur. eius uestigia. etiam nunc
manent tria. quod saturni. sanum in faucibus. quod saturnia porta quam nunc uocamus
pandanam. et ideo quia post edem saturni in edificiorum legibus priuatis
parietes postea muris sunt scripti. Auentinum appellatur pluribus
nominibus. ab auibus quod eo se abtiberi ferrent aues. et ab rege
albanorum auentino ibidem sepulto. et ab aduentu hominum quod com
mune latinorum ibi templum dianae sit constitutum. et ab aduectu
[illegible] paludibus mons erat. ab reliquis disclusus. Itaque eo

THE TWO BOOKS

ON

The Water Supply of the City of Rome

OF

(SEXTUS) JULIUS FRONTINUS

IVLII FRONTINI
DE AQVIS VRBIS ROMAE
LIBRI II

CUM omnis res ab imperatore delegata intentiorem exigat curam, et me seu naturalis sollicitudo seu fides sedula non ad diligentiam modo uerum ad amorem quoque commissae rei instigent sitque nunc mihi ab Nerua Augusto, nescio diligentiore an amantiore rei publicae imperatore, aquarum iniunctum officium ad usum, tum ad salubritatem atque etiam securitatem urbis pertinens, administratum per principes semper ceiuitatis nostrae uiros: primum ac potissimum existimo, sicut in ceteris
2 negotiis institueram, nosse quod suscepi. neque enim ullum omnis actus certius fundamentum crediderim, aut aliter quae facienda quaeque uitanda sint posse decerni, aliutue tam indecorum tolerabili uiro, quam delegatum officium ex adiutorum agere praeceptis, quod fieri necesse est, quotiens imperitia praepositei ad illorum decurrit usum; quorum si necessariae partes sunt ad ministerium, tamen ut manus quaedam et instrumentum agentis. . . . quapropter ea quae ad uniuersam rem pertinentia contrahere potui, more iam per multa mihi officia seruato in ordinem et uelut [in hunc] corpus diducta in hunc commentarium contuli, quem pro formula administrationis *respicere possem.* in aliis autem libris, quos post

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ON

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(SEXTUS) JULIUS FRONTINUS

INASMUCH as every office conferred by the emperor demands especial attention; and inasmuch as I am moved not only to devote diligence, but even love to any matter confided to my care, be it on account of inborn zeal, or by reason of faithfulness in office; and inasmuch as Nerva Augustus, an emperor of whom it is difficult to say whether he devotes more love or more diligence to the common weal, has now conferred upon me the duties of water commissioner, (or water works superintendent, *curator aquarum*), duties contributing partly to the convenience, partly to the health, even to the safety of the city, and from olden time exercised by the most distinguished citizens; I therefore consider it to be the first and most important thing to be done, as has always been one of my fundamental principles in other affairs, to learn thoroughly what it is that I have undertaken.

2. There is indeed no better foundation for any business; nor can it in any other way be determined what is to be done, and what omitted; nor is there for a fair-minded man so debasing a course as to perform the duties of an office intrusted to him according to the directions of assistants: a course, however, which must be followed, whenever an inexperienced official takes refuge in the practical knowledge of his assistants; whose services though necessary for rendering help should nevertheless be only a sort of hand and tool of the principal in charge. . . . It is for this reason that I have set down in this commentary all that I could gather as bearing on the subject matter, after having arranged and codified it in accordance with my habit as already exemplified in other offices, so that I might consult it as a guide in the duties of this.

experimenta et usum conposui, succedentium res acta est; huius commentarii pertinebit fortassis et ad successorem utilitas, set cum inter initia administrationis meae scriptus sit, in primis ad
3 nostram institutionem regulamque proficiet. ac ne quid ad totius rei pertinens notitiam praetermisisse uidear, nomina primum aquarum, quae in urbem Romam influant, ponam; tum per quos quaeque earum et quibus consulibus, quoto post urbem conditam anno perducta sit; dein quibus ex locis et a quoto *miliario* coepisset . . . ac quantum subterraneo riuo, quantum substructione, quantum opere arcuato; post altitudinem cuiusque modulorumque . . . erogationes ab illis factae sint, quantum extra urbem, quantum *intra* urbem unicuique regioni pro suo modo unaquaeque aquarum seruiat; quot castella publica [priuataque] sint, et ex is quantum publicis operibus, quantum muneribus — ita enim cultiores appellant — quantum lacibus, quantum nomine [Iulii] Caesaris, quantum priuatorum usibus beneficio principis detur; quod ius *ducendarum* tuendarumque sit earum, quae id sanciant poenae lege, senatus consultis, mandatis principum inrogatae.

LIBER I

4 Ab urbe condita per annos quadringentos quadraginta unum contenti fuerunt Romani usu aquarum, quas aut ex Tiberi aut ex puteis aut ex fontibus hauriebant. fontium memoria cum sanctitate adhuc extat et colitur: salubritatem aegris corporibus afferre creduntur, sicut Camenarum et Apollinis et Iuturnae. nunc autem in urbem influunt aqua Appia, Anio

But my other commentaries were inspired by my own hard-earned practice and experience, and were intended for the benefit of my successors, and this commentary may also be of use to a successor; but, as it has been written at the beginning of my administration, it will serve more especially for my own instruction, and as a guide.

3. And that I may not by chance omit anything which is necessary for the understanding of the whole subject matter, I will first put down the names of the waters which are brought to the city of Rome; then by what persons, and under what consuls, and in what year since the founding of the city each of them was brought in; then at what places and at what mile-stones their aqueducts commence; how far they were carried in underground channels, how far on masonry substructures, and how far on arches; then the height of each of them, and the size and number of taps, and what uses are dependent upon them; how much each aqueduct brings to each ward without the city, and how much within the city; how many public delivery tanks there are, and how much is delivered from them to the places of public amusement, how much to the ornamental fountains (*munera*) — as the more educated call them — how much to the water basins, how much to the use of the State (in the name of Caesar), how much for private uses by grants from the emperor; what is the law with regard to the construction and maintenance of the aqueducts; what penalties enforce it under the laws, votes of the Senate, and Imperial edicts that have been enacted.

BOOK I

4. From the foundation of the city for 441 years[1] the Romans were content with the use of the waters which they drew, either from the Tiber, or from wells, or from springs. Springs have held, down to the present day, the name of holy things, and are objects of veneration, having the repute of healing the sick; as for example, the springs of the Prophetic Nymphs (Camenae),[2] of Apollo, and of Juturna.[3] But there now run into the city: the Appian aqueduct,

[1] Until 313 B. C. [2] Livy, i. 21, 3, etc. See Kiepert and Hülsen.

[3] Near it was the Temple of Castor and Pollux, who were reputed to have watered their horses there, after the battle of Lake Regillus.

uetus, Marcia, Tepula, Iulia, Virgo, *Alsietina* quae eadem uocatur Augusta, Claudia, Anio nouus.

5. M. Valerio Maximo P. Decio Mure consulibus, anno post initium Samnitici belli tricesimo aqua Appia in urbem ducta est *ab* Appio Claudio Crasso censore, cui postea *Caeco* fuit cognomen, qui uiam Appiam *a porta* Capena usque ad *urbem* Capuam muniendam curauit. collegam habuit C. Plautium, cui ob inquisitas eius aquae uenas Venocis cognomen datum est. sed quia is intra annum et sex menses deceptus a collega tamquam idem facturo abdicauit se censura, nomen aquae ad Appii tantum honorem pertinuit, qui multis tergiuersationibus extraxisse censuram traditur, donec et uiam et huius aquae ductum consummaret. concipitur Appia in agro Lucullano uia Praenestina inter miliarium septimum et octauum deuerticulo sinistrorsus passuum septingentorum octoginta. ductus eius habet longitudinem a capite usque ad Salinas, qui locus est ad portam Tergeminam, passuum undecim milium centum nonaginta: *ex eo riuus est* supterraneus passuum undecim milium centum triginta, supra terram substructio et *opus* arcuatum proximum portam Capenam passuum sexaginta. iungitur ei ad Spem ueterem in confinio hortorum Torquatianorum *et Epaphroditia*norum[1] ramus Augustae ab Augusto in supplementum eius additus . . . loco nomen . . . † denti Gemellorum. hic uia *Collatina*[2] ad miliarium sextum deuerticulo sinistrorsus passuum nongentorum octoginta proxime uiam Collatiam accipit fontem. cuius ductus usque ad Gemellos efficit riuo subterraneo passuum sex milia trecentos sexaginta. incipit distribui *Appia* imo Publicii cliuo ad portam Trigeminam [qui locus Salinae appellantur].

[1] Lanciani, *Frontino*, 248.

[2] Lanciani, *Frontino*, 249.

Anio Vetus, Marcia, Tepula, Julia, Virgo, Alsietina, which is also called Augusta, Claudia, and Anio Novus.

5. Under the consulate of M. Valerius Maximus and P. Decius Mus,[1] in the thirtieth year after the beginning of the Samnite war,[2] the Appian water was brought into the city by the censor Appius Claudius Crassus, who later received the surname Caecus,[3] who also had charge of the construction of the Appian Way, from Porta Capena[4] to the city of Capua. He had for his colleague C. Plautius, who received the name of Venox (the searcher of springs), on account of his search for the springs of this water; but since Plautius resigned the office of censor before the expiration of the eighteen months,[5] as a result of the erroneous impression that his colleague would do the same, Appius alone enjoyed the honor of giving the aqueduct its name; and it is said of him, that by various contrivances he managed to extend the term of his office as censor until he had completed not only the aqueduct, but also the highway. The intake of the Appia is on the estate of Lucullus on the (Collatian) Praenestine[6] Way, between the seventh and eighth mile-stones, on a cross-road, 780 paces[7] to the left (going from Rome). The aqueduct from the intake to the Salinae at the Porta Trigemina has a length of 11,190 paces; of which 11,130 are in underground channels, and 60 paces above-ground on masonry substructures and on arches near the Porta Capena. With it connects a branch of the Augusta, at the Spes Vetus,[8] in the vicinity of the Torquatian and Plautian gardens, arranged thus as a supplementary supply by Augustus, who at the same time gave it the significant name of the Twins. This branch has its intake on the Praenestine Way, at the sixth mile-stone, on a cross-road, 980 paces to the left, very near the Collatian Way, and the aqueduct extends in an underground channel 6,360 paces before joining the Twins. The distribution of Appia begins at the foot of the Publician steps (acclivity), near the Porta Trigemina, at the place called the Salinae.

[1] 313 B. C.; Middleton, ii. 335.

[2] The Samnite war referred to is the one of 343 B. C.

[3] Livy, ix. 29; Diod. Sic. xx. 36.

[4] Martial, iii. 47, and Kiepert and Hülsen.

[5] The normal term of office.

[6] Lanciani says this should be Collatian. See also Middleton, ii. 336.

[7] The Roman double pace, about 5 feet long, is meant.

[8] Middleton, ii. 198; Livy, xl. 51.

6 Post annos quadraginta quam Appia perducta est, anno ab urbe condita quadringentesimo octogesimo uno M'. Curius Dentatus, qui censuram cum Lucio Papirio Cursore gessit, Anionis qui nunc uetus dicitur aquam perducendam in urbem ex manubiis de Pyrro captis locauit, Spurio Caruilio Lucio Papirio consulibus iterum. post biennium deinde actum est in senatu de consummando eius aquae opere referente . . . † norumi . . . praetore. tum ex senatus consulto duumuiri aquae perducendae creati sunt Curius, *qui eam* locauerat et Fuluius Flaccus. Curius intra quintum diem quam erat duumuirum creatus decessit; gloria perductae pertinuit ad Fuluium. concipitur Anio uetus supra Tibur uicesimo miliario extra portam † RRa . . . nam, ubi partem *dat* in Tiburtium usum. ductus eius habet longitudinem, ita exigente libramento, passuum quadraginta trium milium: ex eo riuus est subterraneus passuum quadraginta duum milium septingentorum septuaginta nouem, substructio supra terram passuum ducentorum uiginti unius.

7 Post annos centum uiginti septem, id est anno ab urbe condita sexcentesimo octauo, Ser. Sulpicio Galba [cum] Lucio Aurelio Cotta consulibus cum Appiae Anionisque ductus uetustate quassati priuatorum etiam fraudibus interciperentur, datum est a senatu negotium Marcio, qui tum praetor inter ciues ius dicebat, eorum ductuum reficiendorum ac uindicandorum. et quoniam incrementum urbis exigere uidebatur ampliorem modum aquae, eidem mandatum a senatu est, ut curaret, quatinus alias aquas quas posset in urbem perduceret. . . . priores ductus restituit *et* tertiam † illiobriorum . . . duxit, cui ab auctore Marciae nomen est. legimus aput Fenestellam, in haec opera Marcio decretum sestertium milies octingenties, et quoniam ad consummandum negotium non sufficiebat spatium praeturae in annum alterum prorogatum. eo tempore

6. Forty years after the construction of Appia, in the year 481[1] from the founding of the city, Manius Curius Dentatus, who was censor along with Lucius Papirius Cursor, contracted to have the waters of the river Anio (now called the Anio Vetus), brought into the city, for the sum realized by the sale of the spoils taken from Pyrrhus. This was in the second consulate of Spurius Carvilius, and of Lucius Papirius Cursor. Two years later the completion of this aqueduct was discussed in the Senate. . . . Upon which a board of two commissioners was elected by vote of the Senate, for the bringing in of the water, namely: Curius, who had let the (original) contract, and Fulvius Flaccus. Curius died within five days of his election as one of the board of commissioners: the honor of completing the work devolved on Fulvius. The intake of the Old Anio is up-stream from Tibur (Tivoli) at the twentieth mile-stone outside the Baranean Gate, where it gives a part of its water to them of Tivoli. Its conduit on account of necessary deviations is 43,000 paces long, of which there are 42,779 paces of underground channel, and 221 paces on substructures above-ground.[2]

7. Subsequently, 127 years from this time, that is in the year 608[3] from the founding of the city, under the consulate of Servius Sulpicius Galba and L. Aurelius Cotta, when the Appia and Old Anio aqueducts had become leaky by reason of age, and water had also been diverted from them by unlawful takings, the Senate commissioned Marcius, who at that time administered the law as Praetor between the citizens, to restore these aqueducts to usefulness and to protect them.[4] And because the growth of the city seemed to demand an increased water-supply, he was also empowered by the Senate to investigate whether he could bring other additional waters into the city. This he did, by bringing to the Capitol by a conduit situated above-ground, the water which from the name of its builder is called Marcia. We read in Fenestella, that 180,000,000 *sestertii*[5] had been appropriated for these works. But, because the term of office of the Praetor was not long enough to complete the commissioned work, the same was

[1] 273 B. C.

[2] Lanciani, *Com. di Frontino*, Plate iv.; Middleton, ii. 336.

[3] 145 B. C.

[4] Dion. Cass., xlix. 42; Pliny, *Nat. Hist.*, xxxi. 41; xxxvi. 121; Middleton, ii. 337.

[5] The *sestertius* was between 4 and 5 cents in value.

decemuiri, dum aliis ex causis libros Sibillinos inspiciunt, inuenisse dicuntur, non esse fas[1] aquam Marciam seu potius Anionem — de hoc enim constantius traditur — in Capitolium perduci,[1] deque ea re in senatu M. Lepido pro collegio[1] uerba faciente actum Appio Claudio Q. Caecilio consulibus, eandemque post annum tertium a Lucio Lentulo retractatam C. Laelio Q. Seruilio consulibus, sed utroque tempore uicisse gratiam Marcii Regis; atque ita in Capitolium esse aquam perductam. concipitur Marcia uia Valeria ad miliarium tricesimum sextum deuerticulo euntibus ab urbe Roma dextrosus milium passuum trium. Sublacensi autem, quae sub Nerone principe primum strata est, ad miliarium tricesimum octauum sinistrorsus intra passus ducentos fontium . . . sub . . . bus † petrei . . . stat immobilis stagni modo colore praeuiridi. ductus eius habet longitudinem a capite ad urbem passuum sexaginta milium et mille septingentorum decem et semis: riuo subterraneo passuum quinquaginta quattuor milium ducentorum quadraginta septem semis, opere supra terram passuum septem milium quadringentorum sexaginta trium: *ex* eo longius ab urbe pluribus locis per uallis opere arcuato passuum quadringentorum sexaginta trium, propius urbem a septimo miliario substructione passuum quingentorum uiginti octo, reliquo opere arcuato passuum sex milium quadringentorum septuaginta duum.

8 Cn. Seruilius Caepio et L. Cassius Longinus, qui Rauilla adpellatus est, censores anno post urbem conditam sexcentesimo uicesimo septimo, M. Plautio Hypsaeo M. Fuluio Flacco cos. aquam quae uocatur Tepula ex agro Lucullano, quem quidam Tusculanum credunt, Romam et in Capitolium adducendam curauerunt. Tepula concipitur uia Latina ad decimum miliarium deuerticulo euntibus ab Roma dextrosus milium passuum duum . . . inde suo *riuo* in urbem perducebatur.

9 Post . . . Agrippa aedilis post primum consulatum imperatore Caesare Augusto II L. Volcatio cos., anno post urbem conditam

[1] Hermes, 6, 248.

extended into the year following. During this time it is said that the Board of Ten[1] found, on consulting the Sibylline Books[2] for another purpose, that it was not right for the Marcian waters, or rather for those of the Anio — for the tradition more usually mentions the latter — to be brought to the Capitol. The matter is said to have been debated in the Senate in the consulship of Appius Claudius and Quintus Caecilius, Marcus Lepidus acting as spokesman (for the Board of Ten); and the question was even revived three years later under the consulship of C. Laelius and Q. Servilius; but the popularity of Marcius Rex carried the day; and thus the water was brought to the Capitol. The intake of Marcia is on the Valerian Way, at the thirty-sixth mile-stone, on a cross-road, 3,000 paces to the right as one comes from Rome. But on the Sublacensian Way, which was first paved under the Emperor Nero, at the thirty-eighth mile-stone, and to the left, it may be seen within a distance of 200 paces, at a place where numberless springs gush forth from caves in the rocks, immovable like unto a pool, and of a deep-green hue. The conduit has a length of 61,710½ paces from the intake to the city; 54,247½ paces of underground conduit; 7,463 on structures above-ground; of which, some distance from the city, and at several places where it crosses valleys, 463 paces on arches; nearer the city, and beginning at the seventh mile-stone, 528 paces on masonry substructure; on other arches, 6,472 paces.

8. The Censors, Cn. Servilius Caepio and L. Cassius Longinus, called Ravilla, in the year 627[3] after the founding of the city, under the consulate of M. Plautius Hypsaeus and M. Fulvius Flaccus, caused the water which is called Tepula to be brought to Rome and to the Capitol from the estate of Lucullus, but which some hold to belong to Tusculum.

The intake of Tepula is on the Latin Way, at the tenth mile-stone, 2,000 paces to the right as one comes from Rome; whence it was brought by its own conduit into the city.

9. Later than this, under the second consulate of the Emperor Caesar Augustus and of L. Volcatius, in the year 719[4] after the

[1] This board was specially charged with the custody of the Sibylline Books.
[2] See Hermes, 4, 248. [3] 127 B. C. [4] 35 B. C.

septingentesimo nono decimo ad miliarium ab urbe duodecimum uia Latina *deuerticulo* euntibus ab Roma dextrorsus milium passuum duum alterius aquae proprias uires collegit et Tepulae riuum intercepit. adquisitae aquae ab inuentore nomen Iuliae datum est ita tamen diuisa erogatione, ut maneret Tepulae appellatio. ductus Iuliae efficit longitudinem passuum quindecim milium quadringentorum uiginti sex S.: opere supra terram passuum septem milium: ex eo in proximis urbem locis a septimo miliario substructione passuum quingentorum uiginti octo, reliquo opere arcuato passuum sex milium quadringentorum septuaginta duum. praeter caput Iuliae transfluit aqua quae uocatur Crabra. hanc Agrippa omisit, seu quia inprobauerat, siue quia Tusculanis possessoribus relinquendam credebat; ea namque est quam omnes uillae tractus eius per uicem in dies modulosque certos dispensatam accipiunt. set non eadem moderatione aquarii nostri partem eius semper in subplementum Iuliae uindicauerunt, nec ut Iuliam augerent, quam hauriebant largiendo conpendi sui gratia. exclusi ergo Crabram et totam iussu imperatoris reddidi Tusculanis, qui nunc forsitan non sine ammiratione eam sumunt ignari cui causae insolitam abundantiam debeant. Iulia autem reuocatis deriuationibus, per quas surripiebatur, modum suum quamuis notabili siccitate seruauit. eodem anno Agrippa ductus Appiae, Anionis, Marciae paene dilapsos restituit et singulari cura conpluribus salientibus [aquis] instruxit urbem.

10 Idem cum iam tertio consul fuisset, C. Sentio *Q.* Lucretio consulibus, post annum tertium decimum quam Iuliam deduxe-

founding of the city, M. Agrippa, when he was Aedile subsequently to his first consulate, at the twelfth mile-stone from the city near the Latin Way, on a cross-road two miles to the right as you go from Rome, collected the sources of another spring, and tapped the conduit of Tepula. The new aqueduct was called Julia by the man who planned it, the supply, however, being so apportioned that the name of the Tepula was not lost. The conduit of Julia is 15,426½ paces long, of which there are 7,000 on arches above-ground; quite near the city, beginning at the seventh mile-stone, 528 on masonry substructures; on other arches 6,472 paces.[1]

Near the intake of Julia, is a brook called Crabra. Agrippa disdained to take in this brook, either because he did not consider it of good quality, or because he thought he was under obligations to leave it for the use of the proprietors at Tusculum; for it is the same which is distributed by turns on fixed days and in determined quantities[2] to the estates of that part of the country. But without the same moderation, our water-men constantly drew upon the greater part of it for increasing the flow in the Julian aqueduct, though not for the purpose of increasing the discharge of this aqueduct, which on the contrary they exhausted, by diverting its waters to their own profit. I therefore cut off the Crabra brook, and gave it again entire, upon the orders of the emperor, to them of Tusculum; who perhaps now get it with great astonishment on their part, and without knowing to what cause to ascribe the unusual abundance. The Julian aqueduct, on the other hand, has regained its normal quantity, and holds it even during notable droughts, by reason of the destruction of the branch pipes through which it was secretly despoiled. In the same year[3] Agrippa rebuilt the nearly ruined aqueducts of Appia, of Anio, and of Marcia; and with superior forethought supplied the city with a large number of ornamental fountains.

10. The same man, after his own third consulship, and under the consulate of C. Sentius and Q. Lucretius, thirteen years[4] after he had

[1] Middleton, ii. 325; Trochner, *Méd. Rom.* 169; Castellum of Aqua Julia; medallion of Severus Alexander. Trophies of Marius on it. Shown in Du Perac's etchings, Vestigj di Roma.

[2] Cicero, *De leg. agr.* iii. 2, 9. See ancient stone map, Fabretti, *De aquis*, etc., Rome, 1738, p. 151.

[3] Pliny, *Nat. Hist.*, xxxvi. 121; Middleton, ii. 342.

[4] 20 B. C. Pliny, *Nat. Hist.*, xxxi. 42; Dion. Cass. xi. 7.

rat, Virginem quoque in agro Lucullano collectam Romam perduxit. dies quo primum in urbe[1] responderit, quintus idus Iunias inuenitur. Virgo appellata est, quod quaerentibus aquam militibus uirguncula uenas quasdam monstrauit, quas secuti qui foderant, ingentem aquae modum inuenerunt. aedicula fonti adposita hanc originem pictura ostendit. concipitur Virgo uia Collatia ad miliarium octauum palustribus locis signino circumiecto continendarum scaturriginum causa. adiuuatur conpluribus aliis adquisitionibus. uenit per longitudinem passuum decem quattuor milium centum quinque: ex eo riuo subterraneo passuum decem duum milium octingentorum sexaginta quinque, supra terram per passus mille ducentos quadraginta: ex eo substructione riuorum locis conpluribus passuum quingentorum quadraginta, opere arcuato passuum septingentorum. adquisitionum ductus riui subterranei efficiunt passus mille quadringentos quinque.

11. Quae ratio mouerit Augustum, prouidentissimum principem, perducendi Alsietinam aquam, quae uocatur Augusta, non satis perspicio, nullius gratiae, immo etiam parum salubrem ideoque nusquam in usus populi fluentem; nisi forte cum opus naomachiae adgrederetur, ne quid salubrioribus aquis detraheret, hanc proprio opere perduxit et quod naumachiae coeperat superesse, hortis adiacentibus et priuatorum usibus ad inrigandum concessit. solet tamen ex ea in Transtiberina regione, quotiens pontes reficiuntur et a citeriore ripa aquae cessant, ex necessitate in subsidium publicorum salientium dari. concipitur ex lacu Alsietino uia Claudia miliario quarto decimo deuerticulo dextrorsus passuum sex milium quingentorum. ductus eius efficit longitudinem passuum uiginti duum milium centum septuaginta duorum, opere arcuato passuum trecentorum quinquaginta octo.

[1] Hermes, 14, 269.

constructed the Julian aqueduct, also brought Virgo[1] to Rome, which is gathered on the estate of Lucullus. The day on which it first flowed into the city, is found to be the fifth before the Ides of June.[2] The name Virgo was given to this aqueduct, because it was a young girl who showed its springs to some soldiers who were seeking to find water. Those who were digging having followed up these springs, found a great quantity of water. There may be seen in a little temple erected near the spring, a painting which represents this tradition.

The intake is on the Collatian Way, at the eighth milestone, in a swampy region. The spring is increased by being walled in with a wall of concrete, made of broken pottery and lime, so as to keep together the primary sources, as also by a number of other tributaries. The waters traverse a length of 14,105 paces; for 12,865 of which they are carried in an underground conduit, for 1,240 above-ground; of which, in a conduit built at several points on masonry substructure, 540 paces; on arches 700; the underground conduits of the tributaries measure 1,405 paces.

11. I do not rightly perceive the motives which caused Augustus, that most cautious ruler, to bring in the Alsietinian water, called Augusta, since it has nothing to commend it; and is, on the contrary, so unwholesome, that on this account it is delivered nowhere for the use of the people; unless it be that, when he undertook to construct his Naumachia,[3] he brought in this water to avoid drawing upon the better sources of supply, and left the surplus of the Naumachia for the adjacent gardens, and for the use of private parties for irrigation. It is customary, however, to draw from it in emergencies, and thus to eke out the supply of the public fountains in the ward beyond the Tiber, whenever the bridges are undergoing repairs and no water can be delivered from this side of the river. The intake is out of the Alsietinian Lake, on the Claudian Way, at the fourteenth mile-stone, on a cross-road, 6,500 paces to the right. Its conduit has a length of 22,172 paces; of which 358 paces are on arches.

[1] Ovid *F.* i. 464; *Pont. Epis.* i. 8, 38. [2] June 9th.

[3] A naumachia (from the Greek word for "sea-fight") was the name given to the artificial lakes prepared for exhibitions of sham naval battles; the same name was also applied to the exhibitions themselves. See Middleton, *Remains of Ancient Rome*, i. 386 and ii. 343. Also Martial, i. 24, and i. 28. Tacitus, *Ann.* xiv. 15; xxxii. 56. Also Ramsay's *Manual of Roman Antiquities*.

12 Idem Augustus in subplementum Marciae, quotiens siccitates egerent auxilio, aliam *aquam* eiusdem bonitatis opere subterraneo perduxit usque ad Marciae riuum, quae ab inuentore adpellatur Augusta. nascitur ultra fontem Marciae. cuius ductus donec Marciae accedat, efficit passus octingentos.

13 Post hos C. Caesar, qui Tiberio successit, cum parum et publicis usibus et priuatis uoluptatibus septem ductus aquarum sufficere uiderentur, altero imperii sui anno, M. Aquila Iuliano P. Nonio Asprenate cos., anno urbis conditae septingentesimo *undenonagesimo* duos ductus inchoauit. quod opus Claudius magnificentissime consummauit dedicauitque Sulla et Titiano consulibus, anno post urbem conditam octingentesimo *tertio* kalendis Augustis. alteri nomen [quae ex fontibus Caerulo et Curtio perducebatur] Claudiae datum. haec bonitatis proximae est Marciae. altera, quoniam duae Anionis in urbem aquae fluere coeperant, ut facilius appellationibus dinoscerentur, Anio nouus uocitari coepit [alias omnis praecedit]; priori Anioni cognomen ueteris

14 adiectum. Claudia concipitur uia Sublacensi ad miliarium tricesimum octauum deuerticulo sinistrosus intra passus trecentos ex fontibus duobus amplissimis et speciosis, Caeruleo qui a similitudine adpellatus est, et Curtio. accipit et eum fontem qui uocatur Albudinus, tantae bonitatis, ut Marciae quoque adiutorio quotiens opus est ita sufficiat, ut adiectione sui nihil ex qualitate eius mutet. Augustae fons, quia Marciam sibi sufficere adparebat, in Claudiam deriuatus est, manente nihilo minus praesidiario in Marciam, ut ita demum Claudiam aquam adiuuaret Augusta, si eam ductus Marciae non caperet. Claudiae ductus habet longitudinem passuum quadraginta sex milium *quadringentorum sex:* ex eo riuo subterraneo passuum triginta sex milium ducentorum triginta, opere supra terram passuum decem milium *centum* septuaginta sex: ex eo opere arcuato in superiori parte pluribus

12. Augustus also conducted another water of equal quality through an underground conduit to the channel of Marcia, for supplementing Marcia during droughts, which conduit is called Augusta after its designer. The intake is further away than that of Marcia; from the intake to its junction with Marcia is a distance of 800 paces.

13. After this, C. Caesar,[1] the successor of Tiberius, because the seven aqueducts did not seem to be sufficient to meet either the public needs or the demands of private luxury, commenced the construction of two aqueducts in the second year of his reign, under the consulate of M. Aquila Julianus, and P. Nonius Asprenas in the year 789[2] after the founding of the city. This work was completed in the most splendid manner by Claudius,[3] and was formally dedicated under the consulate of Sulla and Titianus, in the year 803[4] after the founding of the city, on the first of August. One water, which had its source in the Caerulean and Curtian springs, was called Claudia. This one most nearly equals Marcia in good quality. To the other was given the name of New Anio, so as to distinguish it the better, since now two aqueducts were in use, both called Anio. To the first Anio was given the surname Old.

14. The intake of Claudia is on the Sublacensian Way, at the thirty-eighth mile-stone, on a cross-road, three hundred paces to the left, taking in two very capacious and beautiful wells, the Caerulian (blue one), so called from its appearance, and the Curtian. Claudia also takes in a spring called Albudinus, which is of such purity that whenever there is need of supplementing Marcia, it answers so perfectly, that it in no wise changes the character of Marcia by mixing with it. The spring of Augusta was turned into Claudia, because Marcia seemed plainly to be of sufficient volume by itself; but Augusta remained, nevertheless, a reserve supply to Marcia, the understanding being that Augusta should run into Claudia only when the conduit of Marcia could not carry it. Claudia has a length of 46,406 paces; of which, 36,230 are underground conduit, 10,176 above-ground; of which at various points in the upper reaches 3,076 paces are on arches, and

[1] Caligula.
[2] A. D. 36.
[3] The successor of Caligula.
[4] A. D. 50.

locis passuum trium milium septuaginta sex, et prope urbem a septimo miliario substructione riuorum per passus sexcentos nouem, opere arcuato passuum sex milium quadringentorum nonaginta et unius.

15 Anio nouus uia Sublacensi ad miliarium quadragesimum secundum in Simbruino excipitur ex flumine, quod cum terras cultas circa se habeat soli pinguis et inde ripas solutiores, etiam sine pluuiarum iniuria limosum et turbulentum fluit. ideoque a faucibus ductus interposita est piscina limaria, ubi inter amnem et specum consisteret et liquaretur aqua. sic quoque quotiens imbres superueniunt, turbida peruenit in urbem. iungitur ei riuus Herculaneus oriens eadem uia ad miliarium tricesimum octauum e regione fontium Claudiae trans flumen uiamque. natura est purissimus, set mistus gratiam splendoris sui amittit. ductus Anionis noui efficit passuum quinquaginta octo milia septingentos: ex eo riuo subterraneo passuum quadraginta nouem milia trecentos, opere supra terram passuum nouem milia quadringentos: ex eo substructionibus aut opere arcuato superiori parte pluribus locis passuum duo [decim] milia trecentos, et propius urbem a septimo miliario substructione riuorum passus sexcentos nouem, opere arcuato passuum sex milia quadringentos nonaginta unum. hi sunt arcus altissimi, subleuati in quibusdam locis pedes centum nouem.

16 Tot aquarum tam multis necessariis molibus pyramidas uidelicet otiosas conpares aut cetera inertia set fama celebrata opera Graecorum.

17 Non alienum mihi uisum est, longitudines quoque riuorum cuiusque ductus etiam per species operum conplecti. nam cum maxima huius officii pars in tutela eorum sit, scire praepositum oportet, quae maiora impendia exigant. nostrae quidem sollicitudini non suffecit, singula oculis subiecisse: formas quoque ductuum facere curauimus, ex quibus adparet ubi ualles quantaeque, ubi flumina traicerentur, ubi montium lateribus specus adplicitae maiorem adsiduamque tuendi ac muniendi riui exigant curam.

near the city, beginning at the seventh mile-stone, 609 paces on masonry substructure, and 6,491 on arches.[1]

15. The intake of New Anio is on the Sublacensian Way, at the forty-second mile-stone, in the Simbruinum, and from the river; which flows muddy and discolored even without the effect of rainstorms, because it has rich and cultivated lands adjoining, and, as a result, loose banks; for this reason a settling reservoir was built upstream from the intake, so that in it and between the river and the conduit the water might come to rest and clarify itself. But in spite of this construction the water reaches the city in a discolored condition, whenever there are heavy rains. The Herculanean Brook, which has its source on the same Way, at the thirty-eighth mile-stone, opposite the springs of Claudia and beyond the river and the highway, joins it, being of itself exceedingly clear, but losing the charm of its purity by admixture. The conduit of New Anio measures 58,700 paces; of which 49,300 are underground, 9,400 above-ground; of which at various points in the upper reaches are 2,300 paces on masonry substructure or on arches; and nearer the city, beginning at the seventh mile-stone, 609 paces on masonry substructure, 6,491 paces on arches. These are the highest arches, and at some points are 109 feet high.

16. Will anybody compare the idle Pyramids, or those other useless though much renowned works of the Greeks with these aqueducts, with these many indispensable structures?

17. It has seemed to me not superfluous to examine consecutively the lengths of channel of each aqueduct in its several parts, and in detail; — this because the maintenance of the works is the most important part of the duties of this office, wherefore it is necessary that whoever is placed in charge of them should know which of them are in need of having money spent upon them. But my zeal was not satisfied by a mere personal examination in detail; I also had plans made of the aqueducts, from which it may be seen where there are valleys and how wide they are, and where rivers have been crossed; also where the conduits laid on the hillsides need an extended and continued care for their protection and maintenance. In this way we reap the advantage of having, as it were, the works referred to directly

[1] Pliny, *Nat. Hist.*, xxxvi. 122; Middleton, ii. 344.

hinc illa contingit utilitas, ut rem statim uelut in conspectu habere possimus et deliberare tamquam adsistentes.

18 Omnes aquae diuersa in urbem libra perueniunt. inde fluunt quaedam altioribus locis et quaedam erigi in eminentiora non possunt; nam et colles sensim propter frequentiam incendiorum excreuerunt rudere. quinque sunt quarum altitudo in omnem partem urbis adtollitur, set ex his aliae maiori, aliae leuiori pressura coguntur. altissimus est Anio nouus, proxima Claudia, tertium locum tenet Iulia, quartum Tepula, dehinc Marcia, quae capite etiam Claudiae libram aequat. set ueteres humiliore derectura perduxerunt, siue nondum ad suptile explorata arte librandi, seu quia ex industria infra terram aquas mergebant, ne facile ab hostibus interciperentur, cum frequentia adhuc contra Italicos bella gererentur. iam tamen quibusdam locis, sicubi ductus uetustate dilapsus est, omisso circuitu subterraneo uallium breuitatis causa substructionibus arcuationibusque traiciuntur. sextum tenet librae locum Anio uetus, similiter suffecturus etiam altioribus locis urbis, si ubi uallum summissarumque regionum condicio exigit, substructionibus arcuationibusue erigeretur. sequitur huius libram Virgo, deinde Appia: quae cum ex urbano agro perducerentur, non in tantum altitudinis erigi potuerunt. omnibus humilior Alsietina est, quae Transtiberinae regioni et maxime iacentibus locis seruit.

19 Ex is sex uia Latina intra septimum miliarium contectis piscinis excipiuntur, ubi quasi respirante riuorum cursu limum deponunt. modus quoque earum mensuris ibidem positis initur. *tres* autem earum, Iulia, Marcia, Tepula quae intercepta, sicut supra demonstrauimus, riuo Iuliae accesserat, nunc a piscina eiusdem Iuliae modum accipit ac proprio canali et nomine uenit — hae

before us, and of being able to study them, as though we stood by their side.

18. The several aqueducts reach the city at different elevations. Whence it comes that some deliver water on higher grounds, while others cannot elevate themselves to the higher summits; for the hills have gradually grown higher on account of the accumulation of rubbish produced by the frequent fires. There are five aqueducts whose waters rise to all parts of the city, though some are forced up by a greater, others by a lesser head.

New Anio goes the highest; next to it comes Claudia; the third rank is taken by Julia, the fourth by Tepula; this is followed by Marcia, which equals in height at the intake even Claudia.

The ancients laid the lines of their aqueducts at a lower elevation, be it because the art of levelling had not been highly developed, or because they purposely sunk the aqueducts into the ground, in order that they might not readily be destroyed by the enemy, during the frequent wars with the Italians. But now, whenever an aqueduct has succumbed to old age, to save length, they are in certain parts either placed on a masonry substructure or on arches, at the same time avoiding the subterranean loops originally put around the heads of the valleys. The sixth rank in height is taken by Old Anio, which would likewise be able to supply the higher portions of the city if it were raised up on masonry substructures or on arches, wherever the situation of the valleys and low places made it necessary. Its elevation is followed by that of Virgo, then by that of Appia; both of which, since they were brought from points near the city, were unable to reach such high elevations. Lowest of all is Alsietina, which supplies the ward beyond the Tiber, and the very lowest districts.

19. Of these waters, six are drawn into covered catch-basins, this side of the seventh mile-stone on the Via Latina, in which, resting as it were from their run and taking a new breath, they deposit their sediment. Their volume is also determined by gauges set up in these basins. Thence onward, Julia, Marcia, and Tepula run on the same line; of which Tepula, which was turned, as has above been shown, into the same conduit with Julia, now leaves the basin of Julia and receives its volume from it, and flows in its own conduit and under its own name.

tres a piscinis in eosdem arcus recipiuntur. summus *in* his est Iuliae, inferior Tepulae, dein Marcia. quae ad libram *collis* Viminalis † sco . . . ntea fluentes ad Viminalem usque portam deueniunt. ibi rursus emergunt. prius tamen pars Iuliae ad Spem ueterem excepta castellis Caelii montis diffunditur. Marcia autem partem sui post hortos Pallantianos in riuum qui uocatur Herculaneus deicit. is per Caelium ductus, ipsius montis usibus nihil ut inferior sumministrans, finitur supra portam Cape-
20 nam. Anio nouus et Claudia a piscinis in altiores arcus recipiuntur ita ut superior sit Anio. finiuntur arcus earum post hortos Pallantianos et inde in usum urbis fistulis diducuntur. partem tamen sui Claudia prius in arcus qui uocantur Neroniani ad Spem ueterem transfert. hi directi per Caelium montem iuxta templum diui Claudii terminantur. modum quem acceperunt aut circa ipsum montem aut in Palatium Auentinumque et
21 regionem Transtiberinam dimittunt. Anio uetus citra quartum miliarium infra nouum, qui a *uia* Latina in Lauicanam inter arcus traicit, et ipse piscinam habet. inde intra secundum miliarium partem dat in specum qui uocatur Octauianus et peruenit in regionem uiae nouae ad hortos Asinianos, unde per illum tractum distribuitur. rectus uero ductus secundum Spem ueniens intra portam Exquilinam in altos riuos per urbem
22 diducitur. nec Virgo nec Appia nec Alsietina conceptacula, id est piscinas, habent. arcus Virginis initium habent sub hortis Lucullanis, finiuntur in campo Martio secundum frontem Saeptorum riuos Appiae sub Caelio monte et Auentino actus emergit,

These three run on top of the same arches from the basins onward. The uppermost is Julia; next comes Tepula; then Marcia. These waters, going underground at the elevation of the Viminal Hill, flow up to the Viminal Gate. There they again see the light of day. But first, a portion of Julia is distributed to the delivery tanks[1] of the Caelian Hill, having been diverted at Spes Vetus. But Marcia pours a portion of its waters into the so-called Herculanean Channel, behind the Pallantian Gardens; and though this is conducted along the Caelian Hill, it fails to supply anything to this hill by reason of too low elevation, and ends over Porta Capena.

20. The New Anio and Claudia are carried on high arches from the basins, Anio being the higher of the two. Their arches end behind the Pallantian Gardens, and their waters are distributed thence to the city through pipes. But Claudia first delivers a portion of its waters over the so-called Neronian Arches, at Spes Vetus. These pass along the Caelian Hill and end near the temple of Divus Claudius. Both aqueducts deliver the water which they bring partly upon the Caelian Hill, partly upon the Palatine and Aventine, and to the ward over the Tiber.

21. Old Anio, this side of the fourth mile-stone, passes under the arches of New Anio, which crosses from the Latin Way to the Labican, and has there its catch-basin. It then delivers a part of its supply to the Octavian conduit this side of the second mile-stone, and reaches up to the Asinian Gardens in the vicinity of the New Way, whence it is distributed throughout the surrounding district. But the main conduit which passes Spes Vetus comes within the Esquiline Gate, whence it is distributed within the city in high-lying conduits.

22. Neither Virgo, nor Appia, nor Alsietina has a receiving reservoir or catch-basin. The arches of Virgo commence under the Lucullan Gardens, and end on the Field of Mars in front of the Voting Booths. The conduit of Appia, running along the base of the Caelian and the Aventine, emerges again into daylight, as we have said, under the Publician Steps (acclivity). The conduit of Alsietina

[1] I make out *piscinae* to have been catch-basins, and *castellae* small distributing reservoirs or tanks.

ut diximus, infra cliuum Publicii. Alsietinae ductus post naumachiam, cuius causa uidetur esse factus, finitur.

23 Quoniam auctoris cuiusque aquae et aetates, praeterea origines et longitudines riuorum et ordinem librae persecutus sum, non alienum mihi uidetur, etiam singula subicere et ostendere quanta sit copia quae publicis priuatisque non solum usibus et auxiliis uerum etiam uoluptatibus sufficit, et per quot castella quibusque regionibus diducatur, quantum extra urbem, quantum in urbe, et ex eo quantum lacibus, quantum muneribus, quantum operibus publicis, quantum nomine Caesaris, quantum priuatis usibus erogetur. sed rationis existimo, priusquam nomina quinariarum centenariarumque et ceterorum modulorum, per quos mensura constituta est, proferamus, et indicare quae sit eorum origo, quae uires et quid quaeque appellatio significet, propositaque regula, ad quam ratio eorum et initium computatur, ostendere qua ratione discrepantia inuenerim et quam emendandi uiam sim secutus.

24 Aquarum moduli aut ad digitorum aut ad unciarum mensuram instituti sunt. digiti in Campania et in plerisque Italiae locis, unciae in † pApula cita huc obseruatur. est autem digitus, ut conuenit, sextadecima pars pedis, uncia duodecima. quemadmodum autem inter unciam et digitum diuersitas, ita et ipsius digiti *non* simplex obseruatio est. alius uocatur quadratus, alius rotundus. quadratus tribus quartisdecumis suis rotundo maior, rotundus tribus undecumis suis quadrato minor est, scilicet quia
25 anguli deteruntur. postea modulus nec ab uncia nec ab alterutro digitorum originem accipiens inductus, ut quidam putant, ab Agrippa, ut alii, a plumbariis per Vitruuium architectum in usum urbis exclusis prioribus uenit, appellatus quinariae nomine. qui autem Agrippam auctorem faciunt, dicunt, quod quinque antiqui moduli exiles et uelut puncta, quibus olim aqua cum exigua esset

ends behind the Naumachia, for the supply of which it seems to have been constructed.

23. Having now given the builders and the age of each aqueduct, also their sources, lengths of channel, and order of heights, it seems to me not out of keeping to go more into detail, and to demonstrate how large is the quantity of water which is allotted to public and to private uses, as well as for luxury; and through how many tanks it is conveyed, and in what wards these are located; how much water is distributed within the city walls, how much without, how much is used for water basins, how much for fountains, how much for public structures, how much on account of the State, how much by private consumers. But before I mention the names *quinaria*, *centenaria*, and those of the other ajutages by which water is gauged, I deem it expedient to state what is their origin, what their discharge, capacity, or value, and what each name means; and to show, after presenting the rules according to which their proportions and capacity are computed, how I discovered their discrepancies, and the way I set about to correct them.

24. The ajutages to measure water are arranged either according to digits or inches. Digits are used down to the present day in Campania, and in very many places in Italy; inches in Apulia and elsewhere. The digit, according to common agreement, is the one sixteenth part of a foot,[1] the inch the twelfth; but even as there is a difference between the inch and the digit, so also digits differ among themselves; some are called square, others round. The square digit is greater than the round digit by three fourteenths of itself; the round digit is smaller than the square digit by three elevenths, obviously because the corners are lopped off.

25. At a later period, an ajutage called a *quinaria* came into use in the city, to the exclusion of the former measures; this had its origin neither in the inch, nor in either of the two digit measures named, but was introduced, as some say, by Agrippa, according to others by plumbers acting under the direction of the architect Vitruvius; it was so called, according to those who ascribe it to Agrippa, because five small ajutages or punctures of the old type, according to which water

[1] The Roman foot measured 11.653 ins., U. S. standard; = 0.296 m.

diuidebatur, in unam fistulam coacti sint; qui Vitruuium et plumbarios, ab eo quod plumbea lammina plana quinque digitorum latitudinem habens circumacta in rotundum hunc fistulae modulum efficiat. set hoc incertum est, quoniam cum circumagitur, sicut interiore parte adtrahitur, ita per illam, quae foras spectat, extenditur. maxime probabile est, quinariam dictam a diametro quinque quadrantum, quae ratio in sequentibus quoque modulis usque ad uicenariam durat, diametro per singulos adiectione singulorum quadrantum crescente: ut in senaria, quae sexs quadrantes in diametro habet, et septenaria, quae septem, et deinceps
26 simili incremento usque ad uicenariam. omnis autem modulus colligitur aut diametro aut perimetro aut areae mensura, ex quibus et capacitas adparet. differentiam unciae, digiti quadrati et digiti rotundi, et ipsius quinariae ut facilius dinoscamus, utendum est substantia quinariae, qui modulus et certissimus et maxime receptus est. unciae ergo modulus habet diametri digitum unum et trientem digiti; capit plus, quam *quinaria*, quinariae octaua, hoc est sescuncia quinariae et scripulis tribus et besse scripuli. digitus quadratus in rotundum redactus habet diametri digitum unum et digiti sescunciam sextulam; capit quinariae dextantem. digitus rotundus habet diametri digitum unum; capit quinariae

was formerly dealt out, when the supply was as yet insignificant, were united into one pipe; according to those who ascribe it to Vitruvius and the plumbers, it took its name from the circumstance that a flat sheet of lead five digits wide, made up into a round pipe, will form this ajutage. But this is indefinite; because the plate when made up into a round pipe will be extended on the exterior surface and contracted on the interior surface. The most probable explanation is, that the *quinaria* (or 5-pipe) received its name from the fact of its being five fourths (of a digit) in diameter, a method of designation which still applies in the case of the other ajutages up to the 20-pipe, each size being larger than its predecessor by a quarter; for example, a 6-pipe is six quarters in diameter; a 7-pipe, seven quarters, and so on up to a 20-pipe.

26. But every ajutage is gauged either by its diameter or circumference, or by its area of clear cross-section; from any of which its capacity may be found. To appreciate readily the difference between the inch ajutage, the square digit, and the circular digit, and the *quinariae*, use must be made of the value of the *quinaria*, which ajutage is most accurately determined and best known. The inch ajutage is 1 digit plus ⅓ of a digit in diameter; it contains slightly more than 1 *quinaria* plus ⅛ *quinaria;* that is: 1½ twelfths of a *quinaria* plus 3/288 plus 8/12 of 1/288 more. The square digit converted into its equivalent circle is 1 digit plus 1½ twelfths of a digit plus 1/72 in diameter; it measures 10/12 of a *quinaria.* The circular digit is one digit in diameter; and measures 7/12 plus ½ twelfth plus 1/72 of a *quinaria* in area.[1]

[1] Frontinus' fractions are as follows: —

Uncia,	1/12,	–	Quincunx,	5/12,	⚌ –	Dodrans,	¾,	S ⚌ –
Sextans,	1/6,	⚌ or Z	Semissis,	½,	S	Dextans,	10/12,	S ⚌ ⚌
Quadrans,	¼,	⚌ – or :·	Septunx,	7/12,	S –	Deunx,	11/12,	S ⚌ ⚌ –
Triens,	⅓,	⚌ ⚌ or ::	Bes,	⅔,	S ⚌	Semuncia,	½·1/12,	S or £
						Scripulus,	1/288,	Ɔ

He also uses Sescuncia, 1½ · 1/12, (or ⅛); Duella, 1/36; Sicilicus, 1/48; and Sextula, 1/72; and depends on combinations of these to express exact terms. As an illustration, we can modernize the computations of 26, as follows: A pipe, one inch in diameter, is the same as 1⅓ sixteenths (digits) in diameter; it measures 0.7854 square inches, while a *quinaria* = 0.69026 square inches (being 5/64 of a foot in diameter). Therefore, one inch diam. = somewhat more than 1⅛ *quinaria.* The square digit, reduced to a circle = ¾ inch square so reduced = 9/16 square inches = 0.5625 square inches = 0.846 inches diam. = about 0.8 *quinaria.* The round digit has a diameter of one digit or ¾ inch; and measures 0.4418 square inches = 0.64 *quinaria.*

It is useless to try to test the computations of Frontinus himself from the data now

27 septuncem semunciam sextulam. ceterum moduli, qui a quinaria oriuntur, duobus generibus incrementum accipiunt. est unum, cum ipsa multiplicatur, id est eodem lumine plures quinariae includuntur, in quibus secundum adiectionem quinariarum amplitudo luminis crescit. est autem fere tum in usu, cum plures quinariae impetratae, ne riuus saepius conuulneretur, una fistula excipiuntur in castellum, ex quo singuli suum modum recipiunt.
28 alterum genus est, quotiens non ad quinariarum necessitatem fistula incrementum capit, set ad diametri sui mensuram, secundum quod et nomen accipit et capacitatem ampliat: ut puta quinaria, cum adiectus est ei ad diametrum quadrans, senariam facit. nec iam in solidum capacitatem ampliat; capit enim quinariam unam et quincuncem sicilicum. et deinceps eadem ratione quadrantibus diametro adiectis, ut supra dictum est,
29 crescunt septenaria, octonaria usque ad uicenariam. subsequitur illa ratio, quae constat ex numero digitorum quadratorum, qui area, id est lumine, cuiusque moduli continentur, a quibus et nomen fistulae accipiunt. nam quae habet areae, id est luminis in rotundum coacti, digitos quadratos uiginti quinque, uicenum quinum adpellatur: similiter tricenaria et deinceps pari incremento quinorum digitorum quadratorum usque ad centenum
30 uicenum. in uicenaria fistula, quae in confinio utriusque rationis posita est, utraque ratio paene congruit. nam habet secundum eam computationem, quae in antecedentibus modulis seruanda est, † in diametro quadrantes uiginti, cum diametri eiusdem digiti quinque sint; et secundum eorum modulorum rationem, qui sequuntur, aream habet digitorum quadratorum exiguo minus ui-
31 ginti. ratio fistularum quinariarum usque ad centenum uicenum per omnes modulos ita se habet, ut ostendimus, et omni genere

27. Now the ajutages which are derived from the *quinaria*, get their increase in two ways. The first way is by reason of the number of *quinariae* contained, that is by including several *quinariae* in one orifice, whose area increases according to the number of *quinariae* that are united.

This method is the same as the one ordinarily employed whenever several *quinariae* are delivered into the same delivery tank, out of which each consumer then gets his share, this being done so as not to tap the pipes too often for branch pipes.

28. The second way is followed when the ajutages increase not by multiplication of *quinariae* contained, but by increase of the diameter of the pipe; according to which they get their names and measures of capacity. Thus by adding a quarter digit to the diameter of a *quinaria* we get a 6-pipe; but its capacity is not thereby increased proportionately; for it contains 1 *quinaria* plus $\frac{5}{12}$ plus $\frac{1}{48}$. And by adding quarter digits in the same way as has been shown, we get a 7-, 8-, up to a 20-pipe.

29. For the higher numbers is used the method of gauging by the number of square digits contained in the cross-section that is in the orifice of each ajutage, from which the pipes also received their names; for those which in cross-section, that is, in their circular orifice, have twenty-five square digits, are called 25-pipes; upon the like gauging depends the name of the 30-pipes, and so on progressing by five square digits, up to the 120-pipe.

30. In the 20-pipe, which is on the dividing line between the two methods of gauging, the two methods almost coincide. Because, according to the method to be used in the first-named set of ajutages, it is 20 quarter digits in diameter; and according to the method of computation to be applied to the ajutages that follow these,[1] it has 20 square digits less a fraction.

31. The gauging of all the ajutages from the 5-pipe up to the 120-pipe is made as we have stated; and is applicable to them all; and

available; for in nothing would the various copyists have been so likely to differ as in these matters of arithmetic. Everybody that ever had anything to do with the book, seems to have delighted in tinkering at these chapters, so as to exhibit his arithmetical skill.

[1] 1 square digit = $\frac{9}{16}$ square inch. One 20-pipe = 16. *quinariae* = 16 × .69 square inch = 11.04 square ins. = 19.6 square digits.

inita constat sibi. conuenit et cum is modulis, qui in commentariis inuictissimi et piissimi principis positi et confirmati sunt. siue itaque ratio siue auctoritas sequenda est, utroque commentariorum moduli praeualent. sed aquarii cum manifestae rationi *in* pluribus consentiant, in quattuor modulis nouauerunt, duo-
32 denaria et uicenaria et centenaria et centenum uicenum. et duodenariae quidem nec magnus error nec usus frequens est. cuius diametro adiecerunt digiti semunciam sicilicum capacitati, quinariae *quadrantem*. *in* reliquis autem tribus modulis plus deprenditur. uicenariam exiguiorem faciunt diametro digiti semisse *et semuncia*, capacitate quinariis tribus *et quadrante* et semuncia, quo modulo plerumque erogatur. centenaria autem et centenum uicenum, quibus assidue accipiunt, non minuuntur set augentur. diametro enim centenariae adiciunt digiti bessem et semunciam, capacitati quinarias decem semissem semunciam [sicilicum]. centenum uicenum diametro adiciunt digitos tres septuncem semunciam *sicilicum*, capacitati quinarias sexaginta sex sextantem.
33 ita dum aut uicenariae, qua subinde erogant, detrahunt aut centenariae et centenum uicenum adiciunt, quibus semper accipiunt, intercipiuntur in centenaria quinariae uiginti septem, in centenum uicenum quinariae octoginta sex [uncia]. quod cum ratione ad-

conforms to the ajutages as recorded and confirmed in the records of the most puissant and patriotic of emperors.[1] Whether, therefore, we follow computation or authority, the ajutages of the records are entitled to the greater weight. But the water-men have ventured to make deviations in the case of four of the ajutages, namely, in the 12-, 20-, 100-, and 120-pipe, although they generally conform to the rules.

32. In case of the 12-pipe, the error is not great, nor is its use frequent; they have added 1/24 plus 1/48 of a digit to the diameter, and 3/12 of a *quinaria* to its capacity. But a greater discrepancy exists in case of the other three ajutages. They diminish the 20-pipe by 1/2 of a digit plus 1/24, its capacity by 3 *quinariae* plus 1/4 plus 1/24; and common use is made of this ajutage for delivery. But in case of the 100-pipe, and the 120-pipe, through which they regularly receive water, they do not diminish their capacity, but increase it. For they add to the diameter of the 100-pipe 2/3 plus a half-twelfth of a digit, and to the capacity, 10 *quinariae* plus 1/2 plus 1/24 [plus 1/48]. To the diameter of the 120-pipe they add 3 digits plus 7/12 plus 1/24 plus 1/48; to its capacity, 66 *quinariae* plus 1/6.

33. Thus by subtracting on the one hand from the 20-pipe, with which they generally deliver, and by adding, on the other hand, to the 100- or the 120-pipe, through which they always receive, they intercept (take unlawfully) in case of the 100-pipe, 27 *quinariae;* and in case of the 120-pipe, 86[1/12] *quinariae.*[2] Which may be proven by computation,

[1] The Emperor Trajan is meant.

[2] The various texts are a hopeless confusion of figures.* I have followed Bücheler's Latin edition of Frontinus, but Heaven only knows what Frontinus originally computed and wrote, what changes have been made in the course of centuries of the copyists' dabbling in arithmetic, and of twirling of the pen, and what final errors have been laid on, in the way of surplusage, by the practical part of modern typography. Thus it comes, that the stated figures do not agree with the rules of arithmetic.

Frontinus computes discharges by areas of cross-section only. Then, if the gain by *selling* by *short* measure in a 20-pipe was 3 1/24 *quinariae*, it will have been 15 5/24 *quinariae* for five 20-pipes, or for the amount of one lawful 100-pipe; and will have been 18 6/24 *quinariae*, in the same way, for the amount of one lawful 120-pipe. But by reason of *long* measure in *receiving* water, the gain was stated to have been 10 *quinariae* + 6/12 + 1/24 [+ 1/48], and 66 *quinariae* + 1/6, in case of the 100- and 120-pipes respectively; so that adding these gains made at both ends of the bargain, we arrive at an aggregate gain to the water-men of 25 + 9/12 [+ 1/48]; and of 84 + 10/24 *quinariae*, in case of the 100- and the 120-pipe respectively.

Of course discharges depended then, as now, on the laws of practical hydraulics; on the head acting to produce the discharge; on the precise form and position of the inlet; on the length of pipe, etc. See Chapter V. of the Explanatory Chapters.

* See J. Assoc. Eng'g. Soc., June, 1909, M. L. Holman.

probetur, re quoque ipsa manifestum est. nam et uicenaria, quam Caesar pro quinariis sedecim assignat, non plus erogant quam tredecim, et ex centenaria, quam ampliauerunt eque *centenum uicenum* certum est illos non erogare nisi ad artiorem numerum, quia Caesar secundum suos commentarios, cum ex quaque centenaria expleuit quinarias octoginta unam semissem, item ex centenum uicenum quinarias nonaginta octo, tamquam
34 exhausto modulo desinit distribuere. In summa moduli sunt XX quinque. omnes consentiunt et rationi et commentariis exceptis his quattuor, quos aquarii nouauerunt. omnia autem quae mensura continentur, certa et immobilia congruere sibi debent; ita enim uniuersitati ratio constabit. et quemadmodum uerbi gratia sextarii ratio ad cyatos, modii uero et ad sextarios et ad cyatos respondet: ita et quinariarum multiplicatio in amplioribus modulis seruare consequentiae suae regulam debet. alioqui cum in erogatorio modulo minus inuenitur, in acceptorio plus, adparet non errorem esse set fraudem.

35 Meminerimus omnem aquam, quotiens ex *altiore* loco uenit et intra breue spatium in castellum cadit, non tantum respondere modulo suo set etiam exuberare; quotiens uero ex humiliore, id est minore pressura, longius ducitur, segnitia ductus modum quoque deperdere; et ideo secundum hanc rationem aut onerandam esse erogatione aut releuandam.

36 Set et *calicis* positio habet momentum. in rectum et ad libram conlocatus modum seruat, ad cursum aquae obpositus et deuexus amplius rapit, ad latus praetereuntis aquae inuersus et supinus, id est ad haustum pronior, segniter et exiguum sumit. est autem calix modulus aeneus, qui riuo uel castello induitur; huic fistulae adplicantur. longitudo eius habere debet digitos non minus duodecim, lumen [id est] capacitatem quanta im-

although manifest of itself. For out of the 16 *quinariae* allotted by Caesar to the 20-pipe, they do not deliver more than 13; and it is equally certain that of the discharge of the 100- and the 120-pipe which they have expanded, they deliver only a part, inasmuch as Caesar has made delivery according to his grant when out of a 100-pipe he gives 81 *quinariae* plus ½, and similarly out of a 120-pipe 98.

34. In all there are twenty-five ajutages. They all conform to their computed and recorded capacities, excepting those four, which the water-men altered. But everything that is computed and arranged by mensuration should be in harmony in all its parts, the one with the other; for thus only will the results of computation be consistent. And as, for example, a *cyathus*[1] has a fixed relation to a *sextarius*,[2] and similarly a *modius*[3] to both a *cyathus* and a *sextarius*,[4] so must the multiplication of the *quinariae* in case of the larger ajutages proceed in regular order. However, when it is found that the delivery ajutages vent less, and the receiving ajutages vent more than they should, it is plain that this is due not to error, but to fraud.

35. Let us not forget in this connection that every stream of water whenever it comes from a higher point and flows into a delivery tank through a short length of pipe, not only comes up to its measure, but yields, moreover, a surplus; but whenever it comes from a low point, that is, under a less head, and is conducted a tolerably long distance, it will actually shrink in measure by the resistance of its own conduit; so that on these accounts, either an aid or a check is needed for the discharge.

36. But the position of the calix also has an effect. Placed at right angles and level, it maintains its proper measure; set against the current of the water and sloping down, it will consume more; set sloping to one side, so that the water flows by, and inclined with the current, that is, placed less favorably for swallowing the water, it will receive the water slowly, and in a scant quantity. The calix is a bronze ajutage which is tapped into a conduit or delivery tank, and to it the pipes are attached. Its length must be not less than 12 digits; its area of orifice, that is, its capacity, as much as ordered. Bronze seems

[1] About a gill. [2] The Roman pint. [3] The Roman peck.
[4] 12 *cyathi* made 1 *sextarius*; 16 *sextarii*, 1 *modius*.

perata fuerit. excogitatus uidetur, quoniam rigor aeris difficilior ad flexum non temere potest laxari uel coartari.

37 Formulas modulorum qui sunt omnis uiginti et quinque subieci, quamuis in usu quindecim tantum frequentes sint, derectas ad rationem de qua locuti sumus, emendatis quattuor, quos aquarii nouauerant. secundum quod et fistulae omnes, quae opus facient, derigi debent aut, si haec fistulae manebunt, ad quinarias quot capient conputari. qui non sint in usu moduli, in ipsis est adnotatum.

38 [*Vncia* habet diametri *digitum unum et* trientem digiti; *capit plus*, quam quinaria, quinariae sescuncia scripulis tribus et besse scripuli. [digitus quadratus in latitudine et longitudine aequalis est.] digitus quadratus in rotundum redactus habet diametri digitum unum et digiti sescunciam *sextulam*, capit quinariae *dextantem*. digitus rotundus habet diametri digitum unum, capit quinariae septuncem et semiunciam sextulam.]

39 Fistula quinaria: diametri digitum unum ⚌—, *perimetri* digitos tres S ⚌⚌—ↄ III, capit quinariam unam.

40 Fistula *senaria:* diametri digitum unum semis, perimetri digitos IIII S ⚌℔ↄ II, capit quinariam I ⚌⚌—ↄ VII.

41 Fistula septenaria: diametri digitum I S ⁚, perimetri digitos V S, capit quinariam I S ⚌⚌— ℔; in usu non est.

42 Fistula octonaria: diametri digitos duos, perimetri digitos sex ⚌—ↄ X, caput quinarias II S ℔ↄ quinque.

to have been selected on account of its hardness; difficult to bend and not easily extended or contracted.

37. I have described below all the 25 ajutages that there are, although only 15 of them are in use; gauging them according to the method of computation spoken of, and correcting the four which the water-men have altered. According to which principle all ajutages which shall be in use ought to conform, or if those four shall remain in use, they ought to be gauged by the number of *quinariae* that the orifice contains in area. Those that are not in use, are so referred to.

38. The inch ajutage is 1 digit plus ⅓ of a digit in diameter; it contains more than a *quinaria* by 1½ twelfths of a *quinaria* plus 3/288 plus ⅔ of 1/288. The square digit has the same height as breadth. The square digit converted into its equivalent circle is 1 digit plus 1½ twelfths of a digit plus 1/72 in diameter; it measures 10/12 of a *quinaria*. The circular digit is 1 digit in diameter; and measures 7/12 plus a half twelfth plus 1/72 of a *quinaria* in area.

39.[1] The *quinaria:* 1 digit plus 3/12 in diameter; 3 digits plus ½ plus 5/12 plus 3/288 in circumference; it has a capacity of 1 *quinaria*.

40. The 6-pipe: 1 digit and a half in diameter; 4 digits plus ½ plus 2/12 plus 1/24 plus 2/288 in circumference; it has a capacity of 1 *quinaria* plus 5/12 plus 7/288.

41. The 7-pipe: 1 digit plus ½ plus 3/12 in diameter; 5 digits plus a half in circumference; it has a capacity of 1 *quinaria*, plus a half plus 5/12 plus 1/24; is not in use.

42. The 8-pipe: 2 digits in diameter; 6 digits plus 3/12 plus 10/288 in circumference; it has a capacity of 2 *quinariae* plus a half plus 1/24 plus 5/288.

[1] I follow the text of Bücheler's Latin edition of Frontinus in all these admeasurements; and in the choice of words, of numerals, and of fractions have endeavored to reproduce the Latin text, so as to make it possible, mayhap, to trace the ancient mode of reckoning. The Latin text uses symbols, however, instead of vulgar fractions as now written; and Bücheler had not the advantage of being able to study the Montecassino manuscript, or any exact reproduction of it. Nor have I much confidence in the integrity of even the Montecassino manuscript in reproducing the original text of these arithmetical chapters. What some paleographic student may nevertheless yet accomplish in elucidating this and other portions of the *De Aquis*, remains to be experienced.

43 Fistula denaria: diametri digitos duos et semis, perimetri digitos septem S : : ∋ VII, capit quinarias IIII.

44 Fistula duodenaria: diametri digitos III, *perimetri digitos* VIIII ⊐ ⊐ — ∋ III, capit quinarias quinque S ⊐ — ∋ III; in usu non est. [alia] aput aquarios habebat diametri digitos III £ ∋ VI, capacitatis quinarias sex.

45 Fistula quinum denum: diametri digitos III S ⊐ —, perimetri digitos XI S — ⊐ ∋ X, capit quinarias nouem.

46 Fistula uicenaria: diametri digitos quinque £ ∋, perimetri digitos XV S : : ∋ VI, capit quinarias sedecim ⊐ — £. aput aquarios habebat diametri digitos IIII S, capacitatis quinarias XIII.

47 Fistula uicenum quinum: diametri digitos quinque S · £ ∋ V, perimetri digitos decem et septem S ⊐ £ ∋ VII, capit quinarias XX ⊐ ⊐ ∋ VIIII; in usu non est.

48 Fistula tricenaria: diametri *digitos* sex ⊐ ∋ III, perimetri digitos decem et nouem ⊐ ⊐ —, capit quinarias uiginti quattuor ⊐ ⊐ — ∋ quinque.

49 Fistula tricenum quinum: diametri digitos sex S ⊐ ∋ II, perimetri digitos XX S ⊐ ⊐ — £ ∋ IIII, capit quinarias XXVIII S ∋ III; in usu non est.

50 Fistula quadragenaria: diametri digitos septem — £ ∋ III, perimetri digitos XXII ⊐ ⊐ —, capit quinarias XXXII S —.

51 Fistula quadragenum quinum: diametri digitos septem S £ ∋ octo, perimetri digitos XXIII S ⊐ — £, capit quinarias [capit quinarias] XXXVI S — £ ∋ octo; in usu non est.

52 Fistula quinquagenaria: diametri digitos septem S ⊐ ⊐ — £ ∋ quinque, perimetri digitos XXV £ ∋ VII, capit quinarias XL S ⊐ £ ∋ V.

53 Fistula quinquagenum quinum: diametri digitos octo ⊐ ⊐ ∋ decem, perimetri digitos XXVI ⊐ — £, capit quinarias XLIIII S ⊐ — £ ∋ II; in usu non est.

43. The 10-pipe: 2 digits and a half in diameter; 7 digits plus ½ plus 4/12 plus 7/288 in circumference; it has a capacity of 4 *quinariae.*

44. The 12-pipe: 3 digits in diameter; 9 digits plus 5/12 plus 3/288 in circumference; it has a capacity of 5 *quinariae* plus a half, plus 3/12 plus 3/288; is not in use. But with the water-men it measures 3 digits plus 1/24 plus 6/288 in diameter, containing six *quinariae.*

45. The 15-pipe: 3 digits plus a half plus 3/12 in diameter; 11 digits plus a half plus 3/12 plus 10/288 in circumference; it has a capacity of nine *quinariae.*

46. The 20-pipe: 5 digits plus 1/24 plus 1/288 in diameter; 15 digits plus a half plus 4/12 plus 6/288 in circumference; it has a capacity of 16 *quinariae* plus 3/12 plus 1/24. With the water-men it measures 4 digits plus a half in diameter, holding 13 *quinariae.*

47. The 25-pipe: five digits plus a half plus 1/12 plus 1/24 plus 5/288 in diameter; 17 digits plus a half plus 2/12 plus 1/24 plus 7/288 in circumference; it has a capacity of 20 *quinariae* plus 4/12 plus 9/288; is not in use.

48. The 30-pipe: six digits plus 2/12 plus 3/288 in diameter; 19 digits plus 5/12 in circumference; it has a capacity of 24 *quinariae* plus 5/12 plus five 288ths.

49. The 35-pipe: six digits, plus a half plus 2/12 plus 2/288 in diameter; 20 digits plus a half plus 5/12 plus 1/24 plus 4/288 in circumference; it has a capacity of 28 *quinariae* plus a half plus 3/288; is not in use.

50. The 40-pipe: seven digits plus 1/12 plus 1/24 plus 3/288 in diameter; 22 digits plus 5/12 in circumference; it has a capacity of 32 *quinariae* plus ½ plus 1/12.

51. The 45-pipe: seven digits plus ½ plus 1/24 plus eight 288ths in diameter; 23 digits plus ½ plus 3/12 plus 1/24 in circumference; it has a capacity of 36 *quinariae* plus ½ plus 1/12 plus 1/24 plus eight 288ths; is not in use.

52. The 50-pipe: seven digits plus ½ plus 5/12 plus 1/24, plus five 288ths in diameter; 25 digits plus 1/24 plus 7/288 in circumference; it has a capacity of 40 *quinariae* plus ½ plus 2/12 plus 1/24 plus 5/288.

53. The 55-pipe: eight digits plus 4/12 plus ten 288ths in diameter; 26 digits plus 3/12 plus 1/24 in circumference; it has a capacity of 44 *quinariae* plus ½ plus 3/12 plus 1/24 plus 2/288; is not in use.

54 Fistula sexagenaria: diametri digitos VIII S ⊐ £ ∋ octo, perimetri digitos XXVII ⊐ ⊐ − £, capit quinarias XL octo S ⊐ ⊐ ∋ XI.

55 Fistula sexagenum quinum: diametri digitos nouem − ∋ III, perimetri *digitos* XX octo S −, capit quinarias quinquaginta duas S ⊐ − £ ∋ octo; in usu non est.

56 Fistula septuagenaria: diametri digitos nouem ⊐ ⊐ − ∋ sex, perimetri digitos XXIX S ⊐, capit quinarias LVII ∋ V.

57 Fistula septuagenum quinum: diametri digitos nouem S ⊐ − ∋ sex, perimetri digitos XXX S ⊐ ∋ VIII, capit quinarias LXI − ∋ II; in usu non est.

58 Fistula octogenaria: diametri digitos decem − ∋ II, perimetri digitos XXXI S ⊐ £, capit quinarias LXV ⊐.

59 Fistula octogenum quinum: diametri digitos decem ⊐ ⊐ £ ∋ septem, perimetri digitos XXXII S ⊐ ∋ IIII, *capit quinarias* LXVIIII ⊐ −; in usu non est.

60 Fistula nonagenaria: diametri digitos decem S ⊐ ∋ X, perimetri digitos triginta tres S − £ ∋ II, capit quinarias septuaginta tres ⊐ − £ ∋ V.

61 Fistula nonagenum quinum: diametri digitos X S ⊐ ⊐ − £ ∋VIIII, perimetri digitos XXXIIII S £, capit quinarias LXXVII ⊐ ⊐ £ ∋ II; in usu non est.

62 Fistula centenaria: diametri digitos XI ⊐ − ∋ VIIII, perimetri digitos XXXV ⊐ ⊐ − £, capit quinarias octoginta unam ⊐ ⊐ − ∋ X. aput aquarios habebat diametri digitos XII, capacitatis quinarias nonaginta II.

63 Fistula centenum uicenum: diametri digitos duodecim ⊐ ⊐ ∋ VI, perimetri digitos XXXVIII S ⊐ ⊐, capit quinarias LXXXXVII S ⊐ −. aput aquarios habebat diametri digitos XVI, capacitatis quinarias centum sexaginta tres S ⊐ ⊐ −, qui modus duarum centenariarum est.

54. The 60-pipe: 8 digits plus ½ plus 2/12 plus 1/24 plus eight 288ths in diameter; 27 digits plus 5/12 plus 1/24 in circumference; it has a capacity of 40 and eight *quinariae* plus ½ plus 4/12 plus 11/288.

55. The 65-pipe: nine digits plus 1/12 plus 3/288 in diameter; 20 and eight digits plus ½ plus 1/12 in circumference; it has a capacity of fifty-two *quinariae* plus ½ plus 3/12 plus 1/24 plus eight 288ths; is not in use.

56. The 70-pipe: nine digits plus 5/12 plus six 288ths in diameter; 29 digits plus ½ plus 2/12 in circumference; it has a capacity of 57 *quinariae* plus 5/288.

57. The 75-pipe: nine digits plus ½ plus 3/12 plus six 288ths in diameter; 30 digits plus ½ plus 2/12 plus 7/288 in circumference; it has a capacity of 61 *quinariae* plus 1/12 plus 2/288; is not in use.

58. The 80-pipe: ten digits plus 1/12 plus 2/288 in diameter; 31 digits plus ½ plus 2/12 plus 1/24 in circumference; it has a capacity of 65 *quinariae* plus 2/12.

59. The 85-pipe: ten digits plus 4/12 plus 1/24 plus seven 288ths in diameter; 32 digits plus ½ plus 2/12 plus 4/288 in circumference; it has a capacity of 69 *quinariae* plus 3/12; is not in use.

60. The 90-pipe: ten digits plus ½ plus 2/12 plus 10/288 in diameter; thirty-three digits plus ½ plus 1/12 plus 1/24 plus 2/288 in circumference; it has a capacity of seventy-three *quinariae* plus 3/12 plus 1/24 plus 5/288.

61. The 95-pipe: 10 digits plus ½ plus 5/12 plus 1/24 plus 9/288 in diameter; 34 digits plus ½ plus 1/24 in circumference; it has a capacity of 77 *quinariae* plus 4/12 plus 1/24 plus 2/288; is not in use.

62. The 100-pipe: 11 digits plus 3/12 plus 9/288 in diameter; 35 digits plus 5/12 plus 1/24 in circumference; it has a capacity of eighty-one *quinariae* plus 5/12 plus 10/288. With the water-men it has a diameter of 12 digits; having a capacity of ninety and 2 *quinariae*.

63. The 120-pipe: twelve digits plus 4/12 plus 6/288 in diameter; 38 digits plus ½ plus 4/12 in circumference; it has a capacity of 97 *quinariae* plus ½ plus 3/12. With the water-men it has a diameter of 16 digits, having a capacity of one hundred and sixty-three *quinariae* plus ½ plus 5/12, which is the measure of two 100-pipes.

LIBER II

64 Persecutus ea quae de modulis dici fuit necessarium nunc ponam, quem modum quaeque aqua, ut principum commentariis conprehensum est, usque ad nostram curam habere uisa sit quantumque erogauerit; deinde quem ipsi scrupulosa inquisitione praeeunte prouidentia optimi diligentissimique Neruae principis inuenerimus. fuerunt ergo in commentariis in uniuerso quinariarum decem duo milia septingentae quinquaginta quinque, in erogatione decem quattuor milia decem et octo: plus in distributione quam *in* accepto conputabatur quinariis mille ducentis sexaginta tribus. huius rei admiratio, cum praecipuum officii opus in exploranda fide aquarum adque copia crederem, non mediocriter me conuertit ad scrutandum, quemadmodum amplius erogaretur, quam in patrimonio, ut ita dicam, esset. ante omnia itaque capita ductuum metiri aggressus sum, set longe, id est circiter quinariarum decem milibus, ampliorem quam in commentariis modum inueni, ut per singulas demonstrabo.

65 Appiae in commentariis adscriptus est modus quinariarum octingentarum *quadraginta* unius. cuius aquae ad caput inueniri mensura non potuit, quoniam ex duobus riuis constat. ad Gemellos tamen, qui locus est infra Spem ueterem, ubi iungitur cum ramo Augustae, inueni altitudinem aquae pedum quinque, latitudinem pedis unius dodrantis: fiunt areae pedes octo dodrans: centenariae uiginti duae et quadragenaria, quae efficiunt quinarias mille octingentas uiginti quinque: amplius quam commentarii habent, quinariis nongentis octoginta quattuor. erogabat quinarias septingentas quattuor: minus, quam in commentariis adscribitur, quinariis centum triginta septem: et adhuc minus, quam ad Gemellos mensura respondet, quinariis mille centum uiginti una. intercidit tamen aliquantum e ductus uitio, qui quom sit depressior, non facile manationes ostendit, quas esse ex eo adparet quod in plerisque urbis partibus probata aqua obseruatur, [id] quae ex

BOOK II

64. Going on from what it has been necessary to say with regard to the ajutages, I will now give the discharge which each aqueduct was thought to have had, up to my term of office, according to the imperial records, and how much it did deliver; then the discharge, which I found by careful investigation, acting on the prudent suggestion of that best and most active ruler, Nerva (Trajanus).[1] There were, be it noted, in the aggregate twelve thousand seven hundred and fifty-five *quinariae* recorded, fourteen thousand and eighteen discharging water; that is, 1,263 more were reported as delivering water than had been received. Astonished at this, I felt it to be no small part of my duty to investigate, so as to arrive at reliable data concerning the aqueducts and their discharge, and to see how it could come about that more was being delivered than belonged, so to speak, to the estate. So, before doing anything else, I set about measuring the intakes of the conduits; but I found a much greater measure, — that is, one exceeding the recorded figures by about 10,000 *quinariae*, — as I shall show in detail.

65. Appia is credited in the records with 841 *quinariae*. This aqueduct could not be gauged at the intake, because it there consists of two channels; but at the Twins, which is below Spes Vetus, where it joins the branch of the Augusta, I found a depth of water of 5 feet, and a width of one foot plus ¾, making 8¾ square feet of area, twenty-two 100-pipes plus one 40-pipe, which makes 1,825 *quinariae;* more than the records have it by 984 *quinariae*. It was discharging 704 *quinariae;* less than credited in the records by 137 *quinariae*, and, furthermore, less than given by the gauging at the Twins by 1,121 *quinariae*. But a considerable quantity of water is lost through leaks in the conduit, which is not readily seen on account of the depth at which the conduit is located, but whose existence may be inferred from the circumstance that in many wards of the city excellent water is met

[1] Trajan is no doubt meant here. In Book I. Frontinus speaks of "Nerva Augustus;" in Book II. he says "Divus Nerva," the sainted Nerva: whence the argument that Book I. was begun under Nerva, and Book II. finished under Trajan.

ea manat. set et quasdam fistulas intra urbem inlicitas deprehendimus. extra urbem autem propter pressuram librae, quom sit infra terram ad caput pedibus quinquaginta, nullam accipit iniuriam.

66 Anioni ueteri adscriptus est in commentariis modus quinariarum mille quadragentarum quadraginta unius. ad caput inueni quattuor milia trecentas nonaginta octo praeter eum modum qui in proprium ductum Tiburtium deriuatur: amplius, quam in commentariis est, quinariis duobus milibus [octin]gentis quinquaginta septem. erogabantur antequam ad piscinam ueniret quinariae ducentae sexaginta duae. modus in piscina, qui per mensuras positas initur, efficit quinariarum duo milia trecentas sexaginta duas. intercidebant ergo inter caput et piscinam quinariae mille septingentae septuaginta quattuor. erogabat post piscinam quinarias mille trecentas quadraginta octo: amplius, quam in commentariis conceptionis modum significari diximus, quinariis *centum* sexaginta nouem: minus, quam recipi in ductum post piscinam posuimus, quinariis mille decem quattuor. summa quae inter caput et piscinam et post piscinam intercidebat: quinariae duo milia septingentae octoginta octo, quod errore mensurae fieri suspicarer, nisi inuenissem ubi auerterentur.

67 Marciae in commentariis adscriptus est modus quinariarum duum milium centum sexaginta duarum. ad caput mensus inueni quinarias quattuor milia sexcentas nonaginta: amplius, quam in commentariis est, quinariis duobus milibus quingentis uiginti octo. erogabantur antequam ad piscinam perueniret quinariae nonaginta quinque, et dabantur in adiutorium Tepulae quinariae nonaginta duae, item *in* Anionem quinariae centum sexaginta quattuor. summa quae erogabatur ante piscinam: quinariae trecentae quinquaginta una. modus qui in piscina mensuris positis initur cum eo qui circa piscinam ductus eodem canali in arcus excipitur, efficit quinarias duo milia nongentas quadraginta quattuor. summa quae aut erogatur ante piscinam aut *in* arcus recipitur: quinariarum tria milia ducentae nonaginta quinque: amplius, quam in conceptis commentariorum positum est, quinariis mille centum triginta tribus: minus, quam mensurae ad caput actae efficiunt, quinariis mille trecentis nonaginta quin-

with, which is the water that leaks from the conduits. But we have also found illicit pipes within the city. Outside the city, on the other hand, on account of the water level, which at the intake is fifty feet under ground, the conduit has suffered nothing unlawful.

66. Anio Vetus is credited in the records with the quantity, 1,441 *quinariae.* At the intake I found 4,398, exclusive of the quantity which is drawn into the conduit which belongs to them of Tivoli; more than is recorded by 2,957 *quinariae.* There were discharged, before reaching the settling reservoir, 262 *quinariae;* the quantity at the reservoir, determined from the gauges placed there, was 2,362 *quinariae;* so that 1,774 *quinariae* were lost between the intake and the reservoir. Downstream from the reservoir 1,348 *quinariae* were discharged; more than we have stated to be the capacity according to the records by 169[1] *quinariae;* less than we have shown was received into the conduit from the settling reservoir by 1,014 *quinariae.* The total that was lost between the intake and the reservoir and downstream from the reservoir amounted to 2,788[2] *quinariae,* which I should have ascribed to error in measurement, had I not found where it was diverted.

67. Marcia is credited in the records with the quantity, 2,162 *quinariae.* Gauging it at the intake, I found 4,690 *quinariae;* more than is in the records by 2,528 *quinariae.* There were discharged before Marcia reaches the settling reservoir 95 *quinariae,* and 92 *quinariae* are given to supplement Tepula, likewise 164 *quinariae* to Anio; the aggregate discharged before reaching the reservoir is 351 *quinariae.* The quantity at the catch basins computed from the gauges placed there, along with that which is conducted around the basins and is carried upon arches, is 2,944 *quinariae.* The aggregate of what is either discharged upstream from the reservoir or received on the arches is 3,295 *quinariae;* more than is set down in the schedule of the records by 1,133 *quinariae;* less than the gaugings taken at the intake by 1,395 *quinariae.* Eighteen hundred and forty *quinariae* were discharged after passing the reservoir; less than we have said was set down in the records by 227[3] *quinariae;* less than is taken from the

[1] 1,441—262=1,179. And 1,348=1,179+169. [2] 1,774+1,014=2,788.
[3] 2,162—1,840—95=227.

que. erogabat post piscinam quinarias mille octingentas quadraginta: minus, quam in commentariis conceptionis *modum* significari diximus, quinariis ducentis uiginti septem: minus, quam ex piscina in arcus recipiuntur, [sunt] quinariis mille centum quattuor. summa utraque quae intercidebat aut inter caput et piscinam aut post piscinam: quinariarum duo milia ID, quas sicut in ceteris pluribus locis intercipi deprehendimus. non enim eas cessare manifestum est et ex hoc [eo] quod *ad* caput praeter eam mensuram, quam conprehendisse nos capacitate ductus posuimus, effunduntur amplius trecentae quinariae.

68 Tepulae in commentariis adscriptus est modus quinariarum quadringentarum. huius aquae fontes nulli sunt; uenis quibusdam constabat, quae interceptae sunt in Iulia. caput ergo eius obseruandum est a piscina Iuliae. ex ea enim primum accipit quinarias centum nonaginta, deinde statim ex Marcia quinarias nonaginta duas, praeterea ex Anione nouo ad hortos Epaphroditianos quinarias centum sexaginta tres. fiunt omnes quinariae quadringentae quadraginta quinque: amplius, quam in commentariis, quinariis quadraginta quinque, quae in erogatione conparent.

69 Iuliae in commentariis adscriptus est modus quinariarum sexcentarum quadraginta nouem. ad caput mensura iniri non potuit, quoniam ex pluribus adquisitionibus constat, set *ad* sextum ab urbe miliarium uniuersa in piscinam recipitur, ubi modus eius manifestis mensuris efficit quinarias mille ducentas sex: amplius quam in commentariis, quinariis quingentis quinquaginta septem. praeterea accipit prope urbem post hortos Pallantianos ex Claudia quinarias centum sexaginta duas. est omne Iuliae in acceptis: quinariae mille trecentae sexaginta octo. ex eo dat in Tepulam quinarias centum nonaginta, erogat suo nomine octingentas tres. fiunt quas erogat quinariae nongentae nonaginta tres: amplius, quam in commentariis habet, quinariis trecentis quadraginta quattuor: minus, quam in piscina habere posuimus, ducentis decem tribus, quas ipsas aput eos, qui sine beneficiis principis usurpabant, deprehendimus.

70 Virgini in commentariis adscriptus est modus quinariarum [sex] centarum quinquaginta duarum. huius mensuram ad caput

reservoir upon the arches by 1,104 *quinariae*. The aggregate of what was lost either between the intake and the reservoir or downstream from the reservoir was 2,499[1] *quinariae*, the diversion of which, as in case of the other aqueducts, we discovered at several places. For, that there is no lack of such is manifest also from the fact that at the intake, besides the volume that we found in the conduit, over 300 *quinariae* are wasted.

68. Tepula is credited in the records with 400 *quinariae*. This aqueduct has no springs to supply it; it consists only of some veins of water taken from Julia. Its intake is therefore to be set down as beginning with the Julian reservoir, for from this it first receives 190 *quinariae;* then immediately thereafter 92 *quinariae* from Marcia, and further from Anio Novus at the Epaphroditian Gardens 163 *quinariae*. This makes in all 445 *quinariae;* more than in the records by 45 *quinariae;* but they appear in its delivery.

69. Julia is credited in the records with a measure of 649 *quinariae*. At the intake the gaugings could not be made, because the intake is composed of several tributaries. But at the sixth mile-stone from the city Julia is wholly taken into the settling reservoir, at which place its measure, according to the plainly visible gauges, amounts to 1,206 *quinariae;* more than set down in the records by 557 *quinariae;* besides this, it receives, near to the city, behind the Pallantian Gardens, from Claudia 162 *quinariae*, making the whole of the *quinariae* received by Julia 1,368. From this it discharges 190 into Tepula, and delivers on its own account 803 *quinariae;* from this we get a total of 993 *quinariae* which it delivers; more than it has in the records by 344 *quinariae;* less than we set it down as having in the reservoir by 213, which is precisely the amount we found was being used by those who had seized upon it without grant from the sovereign.

70. Virgo is credited in the records with a measure of 752 *quinariae*. The gauging could not be made at the intake, because Virgo is made up of several tributaries, and enters its channel with too slow a current. Near to the city, however, at the seventh mile-stone, on the land which now belongs to Cejonius Commodus, and where Virgo has a greater velocity, I made the gauging, and it amounted to 2,504

[1] 4,690—(1,840+351)=2,499.

inuenire non potui, quoniam ex pluribus adquisitionibus constat et lenior riuom intrat. prope urbem tamen ad miliarium septimum in agro qui nunc est Ceionii Commodi, ubi uelociorem † sam cursum habet, mensuram egi quae efficit quinariarum duo milia quingentas quattuor: amplius, quam in commentariis, quinariis mille [octin] gentis quinquaginta duabus. adprobatio nostra expeditissima est; erogat enim omnes quas mensura deprendimus, id est duo milia quingentas quattuor.

71 Alsietinae conceptionis modus nec in commentariis adscriptus est nec in re praesente certus inueniri potuit, cum ex lacu Alsietino et deinde circa Careias ex Sabatino * * quantum aquarii temperauerunt. Alsietina erogat quinarias trecentas nonaginta duas.

72 Claudia abundantior aliis maxime iniuriae exposita est. in commentariis habet non plus quinariis duobus milibus octingentis quinquaginta quinque, cum ad caput inuenerim quinariarum quattuor milia sexcentas septem: amplius, quam *in* commentariis, mille septingentis quinquaginta duabus. adeo autem nostra certior est mensura, ut ad septimum ab urbe miliarium in piscina, ubi indubitatae mensurae sunt, inueniamus quinarias tria milia trecentas decem duas: plus, quam in commentariis, quadringentis quinquaginta septem, quamuis et ex beneficiis ante piscinam eroget et plurimum subtrahi deprehenderimus ideoque minus inueniatur, quam re uera esse debeat, quinariis mille ducentis nonaginta quinque. et circa erogationem autem fraus adparet, quae neque ad commentariorum fidem neque ad eas quas ad caput egimus mensuras, neque ad illas saltem † ad piscinam post tot iniurias sunt, conuenit. solae enim quinariae mille septingentae quinquaginta erogantur: minus, quam commentariorum ratio dat, quinariis mille centum quinque: minus autem, quam mensurae ad caput factae demonstrauerunt, quinariis duobus milibus octingentis quinquaginta septem: minus etiam, quam in piscina inuenitur, quinariis mille quingentis sexaginta duabus. ideoque cum sincera in urbem proprio riuo perueniret, in urbe miscebatur cum Anione nouo, ut confusione facta et conceptio earum et erogatio esset obscurior. quod si qui forte me adquisitionum mensuris blandiri putant, admonendi sunt adeo Curtium et Caeruleum fontes aquae Claudiae

quinariae, being 1,752[1] *quinariae* more than was set down in the records. But proof of the correctness of our gauging is at hand; for Virgo discharges all the *quinariae* we found at the point of gauging, that is, 2,504.

71. The measure of Alsietina is not set down in the records, nor could it be accurately arrived at under present conditions, because it receives from Lake Alsietinus, and afterwards in the vicinity of Careiae from Sabatinus, * * * as much water as pleases the water-men. Alsietina discharges 392 *quinariae*.

72. Claudia, flowing more abundantly than the others, is especially exposed to depredation. In the records it is credited with not more than 2,855 *quinariae*, although I found at the intake 4,607 *quinariae;* more than recorded by 1,752 *quinariae;* but our gauging is all the surer, inasmuch as at the seventh mile-stone from the city, at the settling reservoir, where the gauging is without question, we found 3,312 *quinariae;* more than recorded by 457; although it not only discharges before reaching the reservoir to satisfy private grants, but also, as we detected, is deprived of a great deal secretly, and therefore carries 1,295 *quinariae* less than it actually should carry. It is manifest that there has been fraud somewhere before the delivery of the water, if the amount actually delivered does not agree either with the statements of the records or with the gaugings made by us at the intake, or even with those made at the settling basins, which last were made downstream from the points of leakage that have been named. For there are only 1,750 *quinariae* delivered; less than the computation given in the records by 1,105 *quinariae;* also less than the gauging made at the intake by 2,857 *quinariae;* less also than was found at the reservoir by 1,562 *quinariae;* for which reason, although it arrived in the city perfectly clear in its own conduit, it was mixed within the city with the New Anio, so that by this mixing of the waters their measure as well as their discharge was obscured. But should any one think that I have exaggerated the measure of the sources of Claudia, it should be remembered that the Cacrulean and Curtian springs alone suffice to

[1] The Montecassino manuscript credits Virgo with 652 *quinariae*, and says the gauging gave the quantity 1,852 *quinariae* greater than recorded; either it is wrong in this, or it in wrong in adding up the quantities recorded as running in all the aqueducts.

sufficere ad praestandas ductui suo quinarias quas significaui quattuor milia sexcentas septem, ut praeterea mille sexcentae effundantur. nec eo infitias quin ea quae superfluunt non sint proprie horum fontium; capiuntur enim ex Augusta, quam inuentam in Marciae subplementum, dum illa non indiget, adiecimus fontibus Claudiae, quamuis ne huius quidem ductus omnem aquam recipiat.

73 Anio nouus in commentariis habere ponebatur quinarias tria milia ducentas sexaginta tres. mensus ad caput repperi quinarias quattuor milia septingentas triginta octo: amplius, quam in conceptis commentariorum est, quinariis mille quadringentis septuaginta quinque. quarum adquisitionem non aude me amplecti quo alio modo manifestius probem, quam quod in erogatione ipsorum commentariorum maior pars earum continetur? erogantur enim quinariarum quattuor milia ducentae, cum alioquin in eisdem commentariis inueniatur conceptio non amplius quam trium milium ducentarum sexaginta trium. praeterea intercipi non tantum quingentas XXXVIII, quae inter mensuras nostras et erogationem intersunt, *set* longe ampliorem modum deprendi. ex quo adparet etiam exuberare conprehensam a nobis mensuram, cuius rei ratio est, quod uis aquae rapacior, ut ex largo et celeri flumine excepta, uelocitate ipsa ampliat modum.

74 Non dubito aliquos adnotaturos, quod longe maior copia actis mensuris inuenta sit, quam erat in commentariis principum. cuius rei causa est error eorum, qui ab initio parum diligenter uniuscuiusque *aquae* fecerunt aestimationem. ac ne metu aestatis aut siccitatum in tantum a ueritate eos recessisse credam, obstat quod ipse *actis* mensuris Iulio mense hanc uniuscuiusque copiam, quae supra scripta est, tota deinceps aestate durantem exploraui. quaecumque tamen est causa quae praecedit, illud utique detegitur, decem milia quinariarum intercidisse, dum beneficia sua principes
75 secundum modum *in* commentariis adscriptum temperant. sequens diuersitas est quod alius modus concipitur ad capita, alius

deliver to the conduit the 4,607 *quinariae* above given by me, and that there are 1,600 besides to spare. But at the same time I do not deny that that which is to spare does not really belong to these springs, for it comes from Augusta, which was constructed to supplement Marcia, but is turned into the sources of Claudia as long as Marcia does not need it, though not even the conduit of Claudia itself can carry all this water.

73. New Anio is credited in the records with the quantity 3,263 *quinariae.* Gauging at the intake I found 4,738 *quinariae;* more than the quantity given in the records by 1,475 *quinariae.* In what way could I more clearly show that I have not exaggerated this measure of the total *quinariae* carried than by showing that in the records of delivery most of this water is actually accounted for? For it is stated that 4,200 *quinariae* are delivered; although in the same records the amount carried is given as not more than 3,263; besides this, I have discovered that not only 538, the difference between our gauging and the recorded delivery, is stolen, but a far greater quantity. Whence it appears that the amount measured by me is none too large; the explanation of this is, that the more impetuous stream of water increases the supply, since it comes from a large and rapidly flowing river.

74. I do not doubt that many will be surprised that according to our gaugings, the quantity of water was found much greater than that given in the imperial records; but it should be observed that this error comes from the fault of those who originally failed to measure each of these waters with sufficient exactness. I do not even believe that it was from fear of droughts in the summer that they deviated so far from the truth, for my experience is the other way, since the quantity of each of the aqueducts which is above given results from gaugings taken in the month of July, and from then on the supply remains the same throughout the entire remainder of the summer; but whatever the reason of the above may be, it has been discovered that 10,000 *quinariae* were intercepted; while the amounts granted by the sovereign are limited to the quantities set down in the records.

75. Another variance consists in this: that there is one measure at the intake; another, and by no means smaller one, at the settling

nec exiguo minor in piscinis, minimus deinde distributione continetur. cuius rei causa est fraus aquariorum, quos aquas ex ductibus publicis in priuatorum usus deriuare deprehendimus. sed et plerique possessorum, e quorum agris aqua circumducitur, [unde] formas riuorum perforant, unde fit ut ductus publici
76 hominibus priuatis uel ad hortorum *usus* itinera suspendant. ac de uitiis eiusmodi nec plura nec melius dici possunt, quam a Caelio Rufo dicta sunt in ea contione, cui titulus est 'de aquis,' quae nunc nos omnia simili licentia usurpata utinam non per offensas probaremus: inriguos agros, tabernas, cenacula etiam, corruptelas denique omnes perpetuis salientibus instructas inuenimus. nam quod falsis titulis aliae pro aliis aquae erogabantur, etiam sunt leuiora ceteris uitia. inter ea tamen quae emendationem uidebantur exigere, numerandum est, quod fere circa montem Caelium et Auentinum accidit. qui colles, priusquam Claudia perduceretur, utebantur Marcia et Iulia. sed postquam Nero imperator Claudiam opere arcuato ad Spem exceptam usque ad templum diui Claudii perduxit, ut inde distribueretur, priores non ampliatae set omissae sunt; nulla enim castella adiecit, set isdem usus est, quorum quamuis mutata aqua uetus appellatio mansit.

77 Satis iam de modo cuiusque *et* uelut noua quadam adquisitione aquarum et fraudibus et uitiis quae circa ea erant dictum est. superest ut erogationem, quam confertam et, ut sic dicam, in massa inuenimus, immo etiam falsis nominibus positam, per nomina aquarum, uti quaeque se habet, et per regiones urbis digeramus. cuius conprensionem scio non ieiunam tantum set etiam perplexam uideri posse, ponemus tamen quam breuissime, ne quid uelut formulae officii desit. iis quibus sufficiet cognouisse summa, licebit transire leuiora.

reservoir; and the smallest at the distribution. The cause of this is the fraud of the water-men, whom we have detected diverting water from the public conduits for private use; but a large number of proprietors of land also, whose fields border on the aqueducts, tap the conduits; whence it comes that the public water-courses are brought to a standstill by private citizens, yea, for the watering of their gardens.

76. Concerning misdemeanors of this sort, nothing more nor better needs to be said than was said by Caelius Rufus,[1] in his speech, which is entitled "Concerning Waters." And would that we were not having daily experience by actual infringement of the law that all these misdemeanors are committed just as flagrantly now as then. Irrigated fields, shops, garrets, even; lastly, disorderly houses have we found fitted up with constantly flowing fixtures. For that some waters should be delivered under a forged name in place of other waters belongs to the lesser misdemeanors. But among the frauds that should be rectified is to be mentioned what took place in the vicinity of the Caelian and Aventine Hills. These hills were supplied before the construction of Claudia by the waters of Marcia and Julia; but after the Emperor Nero led Claudia over the arches at Spes Vetus to the temple of Divus Claudius in order to distribute it from here, the first-named waters were not accredited to new accounts but were quietly ignored; for he did not build new delivery tanks for Claudia, but used those that already existed; and the old name of these remained, although the water had become a new one.

77. With this enough has been said about the measure of each water; and if I may so express it, about a new way of acquiring water; about frauds and about offences committed in connection with all this. It remains to account for the supply, which we found given in a lump sum, so to speak, and recorded, moreover, in false entries, stating how much is to be allotted to each aqueduct, and to what wards of the city. I know very well that such a statement will appear not only tedious but also complicated; nevertheless, I will make it as short as possible that nothing may be lacking to the data of (this) office. Those who will be satisfied with knowing the main facts, can skip the details.

[1] B.C. 85-48. Cicero: *Letters ad. Fam.*, 8, 6, 4. *Epist.*, 242. Date, abt. 50 B.C.

78 Fit ergo distributio quinariarum quattuordecim milium decem et octo, ita ut quinariae DCCLXXI, quae ex quibusdam aquis in adiutorium aliarum dantur et bis in speciem erogationis cadunt, semel in conputationem ueniant. ex his diuiduntur extra urbem quinariae quattuor milia sexaginta tres: ex quibus nomine Caesaris quinariae mille septingentae decem et octo, priuatis quinariae ∞ ∞ CCCXXXXV. reliquae intra urbem VIIII milia nongentae quinquaginta quinque distribuebantur in castella ducenta quadraginta septem: *ex* quibus erogabantur sub nomine Caesaris quinariae mille septingentae septem semis, priuatis quinariae tria milia octingentae quadraginta septem, usibus publicis quinariae quattuor milia quadringentae una: ex eo castris * quinariae ducentae septuaginta nouem, operibus publicis septuaginta quinque quinariae ∞ ∞ CCCI, muneribus triginta nouem quinariae CCCLXXXVI, lacibus quingentis nonaginta uni quinariae ∞ trecentae triginta quinque. set et haec ipsa dispensatio per nomina aquarum et regiones urbis partienda est.

79 Ex quinariis ergo quattuordecim milibus decem et octo, quam summam erogationibus omnium aquarum seposuimus, dantur nomine Appiae extra urbem quinariae tantummodo quinque, quoniam humilior † turetia meatoribus. reliquae quinariae sescentae nonaginta nouem intra urbem diuidebantur per regiones secundam IIX VIIII XI XII XIII XIV in castella uiginti: ex quibus nomine Caesaris quinariae centum quinquaginta una, priuatis quinariae centum nonaginta quattuor, *usibus* publicis quinariae trecentae quinquaginta quattuor: ex eo castris I quinariae quattuor, operibus publicis quattuordecim quinariae centum uiginti tres, muneri uni quinariae duae, lacibus nonaginta duobus quinariae ducentae uiginti sex.

80 Anionis ueteris erogabantur extra urbem nomine Caesaris quinariae centum sexaginta nouem, priuatis quinariae CCCCIIII. reliquae quinariae mille quingentae octo semis intra urbem diuidebantur per regiones primam III IIII V VI VII VIII VIIII XII XIIII in castella triginta quinque: ex quibus nomine Caesaris quinariae sexaginta VI S, priuatis quinariae CCCCXC,

78. In enumerating the distribution of the 14,018 *quinariae*, the 771 *quinariae*[1] which are transferred from certain aqueducts to supplement others and are set down twice in exhibiting the distribution, figure only once in the reckoning. Out of this quantity there are delivered outside of the city 4,063 *quinariae:* of which, in the name of Caesar, 1,718 *quinariae;* to private parties, 2,345. The remaining 9,955 are distributed within the city out of 247 delivery tanks; out of these are delivered, in the name of Caesar, 1,707½ *quinariae;* to private parties, 3,847 *quinariae;* for public uses, 4,401 *quinariae;* namely: to . . . camps, 279 *quinariae;* to seventy-five public structures, 2,301 *quinariae;* to thirty-nine ornamental fountains, 386 *quinariae;* to five hundred and ninety-one water-basins, 1,335 *quinariae.* But this schedule must be made to apply also to the several aqueducts and to the several wards of the city.

79. Of the 14,018 *quinariae,* which sum we have stated to be the discharge of all the aqueducts, only five *quinariae* are given from Appia without the city because (its source is so low). The remaining 699 *quinariae* are distributed within the city throughout the second, eighth, ninth, eleventh, twelfth, thirteenth, and fourteenth wards, out of twenty delivery tanks; of these there are furnished in the name of Caesar 151 *quinariae;* to private parties 194 *quinariae;* for public uses 354 *quinariae;* namely: to one camp four *quinariae;* to fourteen public structures 123 *quinariae;* to one ornamental fountain two *quinariae;* to ninety-two water-basins 226 *quinariae.*

80. Out of the Anio Vetus are delivered, outside the city, in the name of Caesar, 169 *quinariae;* to private parties 404 *quinariae.* The remaining 1,508½ *quinariae* are distributed within the city through the first, third, fourth, fifth, sixth, seventh, eighth, ninth, twelfth, and fourteenth wards, out of thirty-five delivery tanks: of which there are furnished in the name of Caesar 66½ *quinariae;* for the use of private

[1] These 771 *quinariae* are made up as follows:

92 from Marcia to Tepula,
164 „ „ „ Anio (Vetus),
190 „ Julia „ Tepula,
163 „ Anio Novus to Tepula,
162 „ Claudia to Julia.

771 *quinariae.*

usibus publicis quinariae quingentae tres: ex eo castris unis quinariae quinquaginta, operibus publicis XIX quinariae centum nonaginta sex, muneribus nouem quinariae octoginta octo, lacibus nonaginta quattuor quinariae ducentae decem et octo.

81 Marciae erogabantur extra urbem nomine Caesaris quinariae CCLXI S. reliquae quinariae mille quadringentae septuaginta duae intra urbem diuidebantur per regiones primam tertiam quartam V VI VII VIII VIIII X XIIII in castella quinquaginta unum: ex quibus nomine Caesaris quinariae CXVI, priuatis quinariae quingentae quadraginta tres, *usibus publicis quinariae* : ex eo* castris IIII quinariae XLIIS, operibus publicis quindecim quinariae XV, muneribus XII quinariae CIIII, lacibus CXIII quinariae CCLVI.

82 Tepulae erogabantur extra urbem nomine Caesaris quinariae LVIII, priuatis quinariae quinquaginta sex. reliquae quinariae CCCXXXI intra urbem diuidebantur per regiones quartam V VI VII in castella XIIII: ex quibus nomine Caesaris quinariae XXXXII, priuatis quinariae CCXXXVII, usibus publicis quinariae quinquaginta: ex eo castris I quinariae duodecim, operibus publicis III quinariae septem, lacibus XIII quinariae XXXII.

83 Iuliae fluebant extra urbem nomine Caesaris quinariae LXXX quinque, priuatis quinariae CXXI. reliquae quinariae quingentae quadraginta octo intra urbem diuidebantur per regiones secundam III V VI VIII X XII in castella decem et septem: ex quibus nomine Caesaris quinariae decem et octo, *priuatis quinariae**, usibus publicis quinariae CCCLXXXIII: ex eo castris * quinariae sexaginta nouem, operibus publicis * quinariae CXXCI, muneribus III quinariae sexaginta septem, lacibus uiginti octo quinariae sexaginta quinque.

84 Virginis nomine exibant extra urbem quinariae ducentae. reliquae quinariae duo milia trecentae quattuor intra urbem diuidebantur per regiones septimam nonam quartamdecimam in castella decem et octo: ex quibus nomine Caesaris quinariae quingentae

parties 490 *quinariae;* for public uses 503 *quinariae;* to one camp 50 *quinariae;* to nineteen public structures 196 *quinariae;* to nine ornamental fountains 88 *quinariae;* to ninety-four water-basins 218 *quinariae.*

81. Out of Marcia are delivered, outside the city, in the name of Caesar 261½ *quinariae.* The remaining 1,472 *quinariae* are distributed within the city through the first, third, fourth, fifth, sixth, seventh, eighth, ninth, tenth, and fourteenth wards, out of fifty-one delivery tanks; of these there are furnished in the name of Caesar 116 *quinariae;* to private parties 543 *quinariae;* for public uses[1] * * * *quinariae;* namely: to four camps 42½ *quinariae;* to fifteen public structures 15 *quinariae;* to twelve ornamental fountains 104 *quinariae;* to 113 water-basins 256 *quinariae.*

82. Out of Tepula are delivered outside the city, in the name of Caesar, 58 *quinariae;* to private parties 56 *quinariae.* The remaining 331 *quinariae* are distributed within the city through the fourth, fifth, sixth, and seventh wards, out of fourteen delivery tanks: of which there are furnished in the name of Caesar 42 *quinariae;* to private parties 237 *quinariae;* for public uses fifty *quinariae;* namely: to one camp twelve *quinariae;* to three public structures seven *quinariae;* to thirteen basins 32 *quinariae.*

83. Out of Julia flow outside the city, in the name of Caesar, 85 *quinariae;* to private parties 121 *quinariae.* The remaining 548 *quinariae* are distributed within the city to the second, third, fifth, sixth, eighth, tenth, and twelfth wards, out of seventeen delivery tanks: of which there are furnished in the name of Caesar 18 *quinariae;* to private parties * * * *quinariae;* for public uses 383 *quinariae;* namely: to * * * camps 69 *quinariae;* to * * * public structures, 181 *quinariae;* to three ornamental fountains 67 *quinariae;* to twenty-eight basins, 65 *quinariae.*

84. Virgo delivers outside the city 200 *quinariae.* The remaining 2,304 *quinariae* are distributed within the city to the seventh, ninth, and fourteenth wards, out of eighteen delivery tanks: of which there are furnished in the name of Caesar 509 *quinariae;* to private

[1] A branch of Marcia supplied the baths of Caracalla, (built A.D. 206). Middleton, ii. 172.

nouem, priuatis quinariae CCCXXXVIII, usibus publicis ∞ centum sexaginta septem: ex eo muneribus II quinariae XXVI, lacibus uiginti quinque quinariae quinquaginta una, operibus publicis sedecim quinariae ∞ CCCLXXX. in quibus per se euripo, cui ipsa nomen dedit, quinariae CCCCLX.

85 Alsietinae quinariae trecentae nonaginta duae. haec tota extra urbem consumitur, nomine Caesaris quinariae trecentae quinquaginta quattuor, priuatis quinariae centum triginta octo.

86 Claudia et Anio nouus extra urbem proprio quaeque riuo erogabantur, intra urbem confundebantur. et Claudia quidem extra urbem dabat nomine Caesaris quinarias CCXLVI, priuatis quinarias CCCCXXX nouem; Anio nouus nomine Caesaris quinarias septingentas uiginti octo. reliquae utriusque quinariae tria milia quadringentae nonaginta octo intra urbem diuidebantur per regiones urbis XIIII in castella nonaginta duo: ex quibus nomine Caesaris quinariae octingentae XVIIII, priuatis quinariae ∞ sexaginta septem, usibus publicis quinariae ∞ XII: ex eo castris nouem quinariae centum quadraginta nouem, operibus publicis decem et octo quinariae CCCLXXIIII, muneribus XII quinariae centum septem, lacibus CC uiginti sex quinariae CCCCXXCI.

parties 338 *quinariae;* for public uses 1,167 *quinariae;* namely: to two ornamental fountains 26 *quinariae;* to twenty-five basins, 51 *quinariae;* to sixteen public structures, 1,380 *quinariae.* Among the public structures are included 460 *quinariae* for the Euripus[1] alone, to which Virgo gave its name.[2]

85. Alsietina has 392 *quinariae.* These were all used outside the city: of which, there are furnished in the name of Caesar 354 *quinariae;* and to private parties 138 *quinariae.*

86. Outside the city Claudia and Anio Novus deliver each from its own channel; within the city they are mixed together. Claudia discharges outside the city, in the name of Caesar, 246 *quinariae;* to private parties 439 *quinariae;* to Anio Novus in the name of Caesar 728 *quinariae.* The remaining 3,498 *quinariae* of the two are distributed within the city through all the 14 wards out of ninety-two delivery tanks: of these, there are furnished in the name of Caesar 819 *quinariae;* to private parties 1,067 *quinariae;* for public uses 1,012 *quinariae;* namely: to nine camps 149 *quinariae;* to eighteen public structures[3] 374 *quinariae;* to twelve ornamental fountains 107 *quinariae;* to 226 basins, 481 *quinariae.*[4]

[1] This word means a channel or canal, and is here supposed by Rondelet to have meant the canal of running water built opposite the seats of the Flaminian Circus, situated in the ninth ward. See also Middleton, ii. 51; Suet., *J. Caesar,* 39.

[2] Virgo also supplied the quantity required by the Thermae of Agrippa; Middleton, ii. 142.

[3] Among them the Baths of Nero; see Middleton, ii. 147. Finished A. D. 69.

[4] Note to Chapters 78 to 86. — The original Ms. of *De Aquis* is a hopeless confusion of figures as regards the statistics given in Chapters 78 to 86. The quantities, as they have come down to us in the Montecassino manuscript, contain a great many errors, and it would be impossible to affirm what are errors, and what is the truth. Poleni seems to have endeavored to reconcile these various figures, so as to make them at least arithmetically consistent. His adjustment of them may perhaps now do as well as any other that can be made, and I give it in the two first of the following tables. The figures contained in Bücheler's Latin edition of Frontinus, taken from those of the original text, are given in the second set of two tables, and it will be evident at once that these last named tables could be adjusted into consistency in an infinite number of ways.

TABLE I.

Names of the Aqueducts	Height of the water in Rome above the Tiber wharves.	Wards within the City receiving Water	Taps in Actual Use	Outside the City			No. of Delivery Tanks	Within the City			
				Total	In the name of Caesar	By private parties		Total	In the name of Caesar	By private parties	For public uses
	Rondelet in ft. Eng.		Quinariae					Quinariae			
Appia	28	2, 8, 9, 11, 12, 13, 14	704	5	0	5	20	699	151	194	354
Anio Vetus	84	1, 3, 4, 5, 6, 7, 8, 9, 12, 14	1,610	508	104	404	35	1,102	60	490	552
Marcia . . .	125	1, 3, 4, 5, 6, 7, 8, 9, 10, 14	1935	837	269	568	51	1,098	116	543	439
Tepula . . .	128	4, 5, 6, 7	445	114	58	56	14	331	34	247	50
Julia	133	2, 3, 5, 6, 8, 10, 12	803	206	85	121	17	597	18	196	383
Virgo . . .	35	7, 9, 14	2,504	200	. . .	200	18	2,304	549	338	1,417
Alsietina . .	(?)	Outside the city	392	392	254	138	..	0	. . .	. . .	. . .
Claudia . . .	158	In all the 14 wards	5,625	1,801	217	439	92	3,824	779	1,839	1,206
Anio Novus	158				731	414					
Totals . . .			14,018	4,063	1,718	2,345	247	9,955	1,707	3,847	4,401

Remark. — These figures are as adjusted by Poleni and others so as to conform to the rules of arithmetic.

TABLE II.

Names of the Aqueducts	For public uses within the city	For camps		For public structures		For ornamental fountains		For water basins	
	Quinariae	Number	Quinariae	Number	Quinariae	Number	Quinariae	Number	Quinariae
Appia	354	1	3	14	123	1	2	92	226
Anio Vetus	552	1	50	18	196	9	88	94	218
Marcia . . .	439	4	41	15	41	12	104	113	253
Tepula . . .	50	1	12	3	7	..	. . . .	13	31
Julia	383	3	69	10	182	3	67	28	65
Virgo	1,417	..	. . .	16	1,330	2	26	25	61
Alsietina . .	. . . .	..	. . .	. . .	. . . .	..	. . . .	. . .	. . .
Claudia . . . Anio Novus	1,206	9	104	18	522	12	99	226	481
Totals . . .	4,401	19	279	94	2,401	39	386	591	1,335

Remark. — These figures are as adjusted by Poleni and others so as to conform to the rules of arithmetic.

TABLE III.

Names of the Aqueducts	Height of the water in Rome above the Tiber wharves.	Wards within the city receiving water	Taps in actual use	Outside the City			No. of delivery tanks	Within the City			
				Total	In the name of Caesar	By private parties		Total	In the name of Caesar	By private parties	For public uses
	Rondelet in ft. Eng.		Quinariae					Quinariae			
Appia	28	2, 8, 9, 11, 12, 13, 14	704	5	0	5	20	699	151	194	354
Anio Vetus	84	1, 3, 4, 5, 6, 7, 8, 9, 12, 14	262 1,348	..	169	404	35	1,508.5	66.5	490	503
Marcia . . .	125	1, 3, 4, 5, 6, 7, 8, 9, 10, 14	95 1,840	..	261 5	. . .	51	1,472	116	543	(?)
Tepula . . .	128	4, 5, 6, 7	92 190 163	..	58	56	14	331	42	237	50
Julia	133	2, 3, 5, 6, 8, 10, 12	803	..	85	121	17	548	18	(?)	383
Virgo	35	7, 9, 14	2504	200	. . .	. . .	18	2,304	509	338	1,167
Alsietina . .	(?)	Outside the city	392	392	354	138	..	0	. . .	. . .	. . . .
Claudia . . .	158	In all the 14 Wards (1,750-162)	(1,588)	..	246	439	92	3,498	819	1,067	1,012
Anio Novus	158	(4,200-163)	(4,037)	..	728	. . .					
Totals . . .			14,018	4,063	1,718	2,345	247	9,955	1,707.5	3,847	4,401

Remark. — These figures are as given in the original Montecassino codex. (?) means an omission due to a defect in the manuscript.

TABLE IV.

Names of the Aqueducts	For public uses within the city	For camps		For public structures		For ornamental fountains		For water basins	
	Quinariae	Number	Quinariae	Number	Quinariae	Number	Quinariae	Number	Quinariae
Appia	354	1	4	14	123	1	2	92	226
Anio Vetus	503	1	50	19	196	9	88	94	218
Marcia . . .	(?)	4	42.5	15	15	12	104	113	256
Tepula . . .	50	1	12	3	7	..	. . .	13	32
Julia	383	(?)	69	(?)	181	3	67	28	65
Virgo	1,167	..	. . .	16	1,380	2	26	25	51
Alsietina . .	. . . .	..	. . .	..	. . . .	..	. . .	. . .	. . . .
Claudia . . . Anio Novus	1,012	9	149	18	374	12	107	226	481
Totals . . .	4,401	(?)	279	75	2,301	39	386	591	1,335

Remark. — These figures are as given in the Montecassino original codex. (?) means an omission due to a defect in the manuscript.

87 Haec copia aquarum ad Neruam imperatorem usque conputata ad hunc modum discribebatur. nunc prouidentia diligentissimi principis quicquid aut fraudibus aquariorum intercapiebatur aut inertia peruertebatur, quasi noua inuentione fontium adcreuit. ac prope duplicata ubertas est et tam sedula deinde partitione distributa, ut regionibus quibus singulae seruiebant aquae plures darentur, tamquam Caelio et Auentino in quos sola Claudia per arcus Neronianos ducebatur, quo fiebat ut quotiens refectio aliqua interuenisset, celeberrimi colles sitirent. quibus nunc plures aquae et in primis Marcia reddita amplo opere a Spe in Auentinum usque perducitur. adque etiam omni parte urbis lacus tam noui quam ueteres plerique binos salientes diuersarum aquarum acceperunt, ut si casus alterutram impedisset, altera sufficiente non
88 destitueretur usus. sentit hanc curam imperatoris piissimi Neruae principis sui regina et domina orbis in dies [quae terrarum dea consistit, cui par nihil et nihil secundum], et magis sentiet salubritas eiusdem [aeternae urbis] aucto castellorum, operum, munerum et lacuum numero. nec minus ad priuatos commodum ex incremento beneficiorum eius diffunditur: illi quoque qui timidi inlicitam aquam ducebant, securi nunc ex beneficiis fruuntur. ne pereuntes quidem aquae otiosae sunt: alia munditiarum facies, purior spiritus, et causae grauioris caeli quibus aput ueteres urbis infamis aer fuit, *sunt* remotae.[1] non praeterit me, deberi operi nouae erogationis ordinationem; set haec cum incremento adiunc-serimus; intelligi oportet, non esse ea ponenda nisi consummata

[1] Hermes [illegible] Theogr. [illegible] n. 45.

87. This is the schedule of the amounts of water distributed or available down to the time of the Emperor Nerva (Trajanus).[1] But now, by the foresight of the most painstaking of sovereigns, whatever had been unlawfully drawn by the water-men, or had been wasted as the result of official negligence, has been recovered; this was practically equivalent to the finding of new sources of supply. And in fact the supply was almost doubled, and was distributed so carefully thereafter, that wards which had previously been supplied by only one aqueduct now received the water of several; as, for example, the Caelian and Aventine Hills, to which Claudia alone had been brought on the arches of Nero, whence it often happened, that whenever this aqueduct had to be repaired, these densely inhabited hills suffered a drought. These are now supplied by several aqueducts, above all, by Marcia, which has been rebuilt and carried on conspicuous structures from Spes (Vetus) to the Aventine. In all parts of the city also, the basins, new and old, have been connected for the greater part with two pipes of different aqueducts, so that if by any accident the supply of one or the other should fail, they will get water from the other and the use of the basins be thus kept up.

88. The effect of this care displayed by the Emperor Nerva,[1] most patriotic of rulers, is felt from day to day by the present queen and empress of the world; and will be felt still more in the improved health of the city, as a result of the increase in the number of the tanks, reservoirs, fountains, and water-basins. No little advantage accrues also to private consumers from the increase in number of private grants; and those who with fear drew water unlawfully, draw their supply now free from care, by grant from the sovereign. Not even the waste water is lost; the cleanliness of the city, too, is greatly improved; the air is purer; and the causes of the pestilence, which gave the air of the city so bad a name with the ancients, are now removed.[2] I am well aware that I ought to indicate in detail the manner of the new distribution; but this I will add when the works are done; it must be understood that no account ought to be given until they are complete.

[1] The Emperor Trajan is meant.

[2] See H. Jordan, in Hermes, 14 (1879), 269. Also, the same in Topogr. i. 1, 149, note 45.

89 fuerint. quid quod nec hoc diligentiae principis, quam exactissimam ciuibus suis praestat, sufficit, parum praesidii *usibus* ac uoluptatibus nostris contulisse sese credentis, quod tantam copiam adiecit, nisi eam ipsam sinceriorem iocundioremque faciat? operae pretium est ire per singula, per quae ille occurrendo uitiis quarundam uniuersis adiecit utilitatem. etenim quando ciuitas nostra, cum uel exigui imbres superuenerant, non turbulentas limosasque aquas habuit? nec quia haec uniuersis ab origine natura est, aut quasi istud incommodum sentire debeant quot capiuntur ex fontibus, in primis Marcia et Claudia ac reliquae, quarum splendor a capite integer nihil aut minimum pluuia inquinatur, si putea
90 extructa et obtecta sint. duae Aniensis minus permanent[1] limpidae, nam sumuntur ex flumine ac saepe etiam sereno turbantur, quoniam Anio quamuis purissimo defluens lacu mollibus tamen cedentibus ripis aufert aliquid quo turbetur, priusquam deueniat in riuos. quod incommodum non solum hibernis ac uernis, set etiam aestiuis imbribus sentit, quo tempore [exiit] gratior aquarum sin-
91 ceritas exigitur.[2] et alter quidem ex his, id est Anio uetus, cum plerisque libra sit inferior, incommodum intra se tenet. nouus autem Anio uitiabat ceteras, nam cum editissimus ueniat et in primis abundans, defectioni aliarum succurrit. imperitia uero aquariorum deducentium in alienos eum specus frequentius, quam explemento opus erat, etiam sufficientes aquas inquinabat, maxime Claudiam quae per multa milia passuum proprio ducta riuo, Romae demum cum Anione permista in hoc tempus perdebat proprietatem. adeoque obuenientibus non succurrebatur, ut pleraeque accerserentur per inprudentiam non uti dignum

[1] Philologus, 32, 567. [2] Philologus, 32, 567.

89. What shall we say of the fact that the painstaking interest which our Emperor evinces for his subjects, could not rest satisfied with what I have already described, but that he thought he would be contributing too little to our needs and gratification merely by such increase in the supply of water, unless he should also increase its purity and its palatableness? It is worth while to examine in detail how he endeavored to enhance the usefulness of all these waters while correcting the defects of only a few of them. For when has our city ever been without muddy or turbid water, even though there had only been moderate rainstorms? And this, not because all the waters are thus affected at their sources, or because this defect ought to be felt in those which are taken from springs; especially not in the case of Marcia and Claudia and the rest, whose purity is perfect at their sources, and which are not, or hardly at all, troubled by rains, if well-basins are built and these are covered over.

90. The two Anios are less limpid, for they are drawn from a river, and are often muddy even in good weather; because the Anio, although running from a lake whose waters are very pure, is nevertheless made turbid by carrying away portions of its loose banks, before it enters the conduits; a defect which it suffers not only in the rainstorms of winter and spring, but also in the showers of summer; at which time of the year a more agreeable state of the water is demanded.

91. Of the two Anios, one, namely Anio Vetus, runs in a lower channel than most of the others, and keeps this muddiness therefore to itself. But the New Anio spoiled all the others, because, coming from a higher position and flowing more abundantly, it was used to eke out the supply of the others; but by the unskilfulness of the water-men, who let it flow into the other conduits oftener than there was any need, it spoiled also the waters of those aqueducts that had a plentiful supply; especially Claudia, which, flowing within the city in its own conduit many thousand paces, finally lost its own qualities, as a result of its mixture with Anio, — at least it did until recently. And so far were the supplementary waters from doing any good that many were brought in heedlessly, by those who had charge of the distribution and who did not give it the proper care. So that we

erat aquas partientium. Marciam ipsam splendore et frigore gratissimam balneis ac fullonibus et relatu quoque foedis min-
92 isteriis deprehendimus seruientem. omnes ergo discerni placuit, tum singulas ita ordinari ut in primis Marcia potui tota seruiret et deinceps reliquae secundum suam quaeque qualitatem aptis usibus assignarentur sic ut Anio uetus pluribus ex causis quo inferior excipitur, minus salubris in hortorum rigationem
93 adque in ipsius urbis sordidiora exiret ministeria. nec satis fuit principi nostro ceterarum restituisse copiam et gratiam; Anionis quoque noui uitia excludi posse uidit. omisso enim flumine repeti ex lacu qui est super uillam Neronianam Sublaquensem, ubi limpidissimus est, iussit. nam cum oriatur Anio supra Trebam Augustam, seu quia per saxosos montes decurrit paucis circa ipsum oppidum obiacentibus cultis, seu quia lacuum altitudine in quos excipitur uelut defaecatur, imminentium quoque nemorum opacitate inumbratus, frigidissimus simul ac splendidissimus eo peruenit. haec tam felix proprietas aquae omnibus dotibus aequatura Marciam, copia uero superatura ueniet in locum deformis illius ac turbidae, nouum auctorem imperatorem Caesarem Neruam Traianum Augustum praescribente titulo.

94 Sequitur ut indicemus quod ius ducendae tuendaeque sit aquae, quorum alterum ad cohibendos intra modum impetrati beneficii priuatos, alterum ad ipsorum ductuum pertinet tutelam. in quibus dum altius repeto leges de singulis aquis latas, quaedam aput ueteres aliter obseruata inueni. aput quos omnis aqua in usus publicos erogabatur et cautum ita fuit: 'ne quis priuatus aliam *aquam* ducat, quam quae ex lacu humum accidit' — haec enim sunt uerba [et] legis — id est quae ex lacu abundauit; eam nos caducam uocamus. et haec ipsa non in alium usum quam

have found even Marcia, so charming in its purity and coldness, used for baths, fulling-mills, and I may not say what vile appointments.

92. It was therefore determined to separate them all and then to arrange so that Marcia should serve wholly for drinking purposes, and that the others should be used for purposes adapted to their special qualities. For example, it was ordered for several reasons, that Old Anio should be used for watering the gardens, and for the more dirty uses of the city; because the further from its source its waters are drawn, the less wholesome they are.

93. But it was not sufficient for our ruler to have restored the volume and attractiveness of the other waters; he also recognized the possibility of remedying the defects of the New Anio, and he gave the order to stop drawing directly from the river and to take from the lake lying above the Sublacensian Villa of Nero, there where the Anio is the clearest; for inasmuch as the source of Anio is above Treba Augusta, it reaches this lake in a very cold and clear condition, be it because it runs between rocky hills and because there is but little cultivated land around that hamlet, or because it drops its sediment in the deep lakes into which it is taken; partly also through the effect of the shade of the forests that surround it. These so excellent qualities of the water, which cause it to equal Marcia in all points, and in quantity to exceed it, are now to supersede its former unsightliness and impurity; and the inscription will proclaim as its new founder, Imperator Caesar Nerva Trajanus Augustus.

94. We have further to indicate what is the law with regard to conducting and maintaining the waters; the first treats of the limitation of private parties to the measure of their grants, and the second of the maintenance of the conduits themselves. In examining in ancient writings what was said in detail in these matters in the laws that had been enacted, I found some things different with our forefathers. With them all water was held for the public use, and the law was as follows: *No private person shall conduct other water than that which flows from the basins onto the ground.* For these are the words of the law referring to water which overflows from the troughs, — we call it lapsed water;[1] and even this was not granted for any

[1] That is, water the private right to which has become void.

in balnearum aut fullonicarum dabatur, eratque uectigalis statuta mercede quae in publicum penderetur. aliquid et in domos prin-
95 cipum ciuitatis dabatur concedentibus reliquis. ad quem autem magistratum ius dandae uendendaeue aquae pertinuerit, in iis ipsis legibus uariatur. interdum enim ab aedilibus, interdum a censoribus permissum inuenio; set apparet, quotiens in re publica censores erant, ab illis potissimum petitum, cum ii non erant, aedilium eam potestatem fuisse. ex quo manifestum est quanto potior cura maioribus communium utilitatium quam priuatarum uoluptatium fuerit, cum etiam ea aqua quam priuati ducebant ad usum
96 publicum pertineret. tutelam autem singularum aquarum locari solitam inuenio positamque redemptoribus necessitatem certum numerum circa ductus extra urbem, certum *in* urbe seruorum opificum habendi, et quidem ita ut nomina quoque eorum, quos habituri essent in ministerio per quasque regiones, in tabulas publicas deferrent; eorumque operum probandorum curam fuisse penes censores aliquando et aediles, interdum etiam quaestoribus eam prouinciam obuenisse, ut apparet ex S. C. quod factum
97 est C. Licinio et Q. Fabio cos. [censoribus]. quanto opere autem curae fuerit ne quis uiolare ductus aquamue non concessam deriuare auderet, cum ex multis adparere potest, tum et ex hoc quod circus maximus ne diebus quidem ludorum circensium nisi aedilium aut censorum permissu inrigabatur, quod durasse etiam postquam res ad curatores transiit sub Augusto, aput Ateium Capitonem legimus. agri uero, qui aqua publica contra legem essent inrigati, publicabantur. mancipi etiam si clam eo † quem aduersus legem fecisset, multa dicebatur. in isdem legibus adiectum est ita: 'ne quis aquam oletato dolo malo, ubi publice

other use than for bathing establishments and for fulling-mills; and it was subject to a tax, for a consideration had to be paid for it, which was turned into the public treasury. Some water was conceded to the houses of the principal citizens, in case the others made no objection.

95. To which authorities belonged the right to grant water or to sell it is variously given in those laws, for at times I found it was left to the aediles, at other times to the censors; but it seems that as often as there were censors in the government these grants were sought from them; if there were none, then the aediles had the power referred to. It is plain from this how much more our forefathers cared for the general good than for private luxury, inasmuch as they caused the State to derive profit even from that water which was conducted to private parties.

96. The maintenance of the several aqueducts, as I found, was let out to contractors, and they were to employ a definite number of workmen on the aqueducts outside the city, and another definite number within the city; in doing this they had to enter in the public records the names of those whom they intended to employ in the service for each ward of the city; and the duty of inspecting their work devolved at times on the aediles and censors, and at times on the quaestors,[1] as may be seen from the vote of the Senate which was passed in the consulate of C. Licinius and Q. Fabius.

97. How much care was taken that no one should injure the conduits, and that no one should draw water that had not been granted, may be seen, among other ways, from the fact that the Circus Maximus could not be watered, even on the days of the Circensian Games, except with the permission of the aediles or censors; which regulation, as may be read in the writings of Ateius Capito, was still in force even after the care of the waters had passed, under Augustus, to commissioners; but lands of which it could be proven that they had been irrigated unlawfully from the public supply were confiscated. A tenant, one of whose slaves infringed the law, even without the knowledge of his master, was punished by a fine. By the same laws it is also enacted as follows: *No one shall with malice pollute the waters*

[1] Jordan, i. 1, 408. The quaestor Aemilius built the first stone bridge. There is a *denarius* showing it. Cohen, *T.* 1 *Aem.* 3.

saliet. si quis oletarit, sestertiorum decem milium multa esto.' [oletato uidetur esse olidam facito.] cuius rei causa aediles curules iubebantur per uicos singulos ex iis qui in unoquoque uico habitarent praediaue haberent binos praeficere, quorum
98 arbitratu aqua in publico saliret. primus M. Agrippa post aedilitatem, quam gessit consularis, operum suorum et munerum uelut perpetuus curator fuit. qui iam copia permittente discripsit, quid aquarum publicis operibus, quid lacibus, quid priuatis daretur. habuit et familiam propriam aquarum, quae tueretur ductus adque castella et lacus. hanc Augustus he-
99 reditate ab eo sibi relictam publicauit. post eum Q. Aelio Tuberone Paulo Fabio Maximo cos. cum res usque in id tempus quasi potestate acta certo iure eguisset, senatus consulta facta sunt ac lex promulgata. Augustus quoque edicto conplexus est, quo iure uterentur qui ex commentariis Agrippae aquas haberent, tota re in sua beneficia translata. modulos etiam, de quibus dictum est, constituit et rei continendae exercendaeque curatorem fecit Messalam Coruinum, cui adiutores dati Postumius Sulpicius praetorius et Lucius Cominius pedarius. insignia eis quasi magistratibus concessa, deque eorum officio senatus consultum factum,
100 quod intra scriptum est. [S. C.] 'Quod Q. Aelius Tubero Paulus Fabius Maximus cos. V. F. de iis qui curatores aquarum publicarum ex consensu senatus a Caesare Augusto nominati essent ordinandis,[1] D. F. R. Q. F. P. D. F. R. I. C. placere huic ordini, eos

[1] Ornandis, Philologus 32, 507.

where they issue publicly. Should any one pollute them, his fine shall be ten thousand sestertii.[1] Therefore the order was given to the Curule aediles to appoint two men in each district from the number of those who lived in it, or owned property in it, in whose care the public fountains should be placed.

98. The first permanent water commissioner was M. Agrippa. He, as one might say, was commissioner mainly of works which he himself had called into existence. This was after his aedileship; and before his aedileship had come his consulship. Inasmuch as the amount of water now available warranted it, he determined how much should be allotted to the public structures, how much to the basins, and how much to private parties. He also kept his own private gang of slaves for the maintenance of the aqueducts and delivery tanks and basins. This gang was given to the State as its property by Augustus, who had received it in inheritance from Agrippa.

99. Following him under the consulate of Q. Aelius Tubero and Paulus Fabius Maximus, votes of the Senate were passed and a law was promulgated in these matters, which until that time had been managed at the option of officials, and had lacked definite rules of law. Augustus also determined by an edict the rights of those who were enjoying the use of water according to Agrippa's records, and made the entire supply dependent upon his own grants. The ajutages, also, of which I have above spoken, were established by him; and for the maintenance and operation of the whole system he named Messala Corvinus commissioner, and gave him as assistants Postumius Sulpicius, ex-praetor, and Lucius Cominius, a junior senator. They were allowed to wear regalia, as though magistrates; and concerning their duties a vote of the Senate was passed, which is here given: —

100. (Vote of the Senate.) *The consuls, Q. Aelius Tubero and Paulus Fabius Maximus, having made a report relating to the duties and privileges of the water commissioners appointed with the advice of the Senate by Caesar Augustus,*[2] *have inquired of the Senate what it would please to order upon the subject; upon which it has been ordered: that those who have the care of the administration of the waters, when*

[1] At that time about two hundred and ninety-two dollars of coin.

[2] 10 B. C.

qui aquis publicis praeessent, cum eius rei causa extra urbem essent, lictores binos et seruos publicos ternos, architectos singulos et scribas [et] librarios, accensos praeconesque totidem habere, quot habent ii per quos frumentum plebei datur. cum autem in urbe eiusdem rei causa aliquid agerent, ceteris apparitoribus isdem praeterquam lictoribus *uti*. utique quibus apparitoribus ex hoc senatus consulto curatoribus aquarum uti liceret, eos diebus decem proximis, quibus senatus consultum factum esset, ad aerarium deferrent; quique ita delati essent, iis praetores aerarii mercedem cibaria, quanta praefecti[1] frumento dando dare deferreque solent, annua darent et adtribuerent; isque eas pecunias sine fraude sua capere liceret. utique tabulas, chartas ceteraque quae eius curationis causa opus essent iis curatoribus [praebenda] Q. Aelius Paulus Fabius cos. ambo alterue, si is uidebitur, adhibitis praetoribus qui aerario praesint, [et] praebenda
101 locent. itemque cum uiarum curatores[que] frumentique parte quarta anni publico fungantur ministerio, ut curatores aquarum iudiciis uacent priuatis publicisque.' Apparitores et ministeria, quamuis perseueret adhuc aerarium in eos erogare, tamen esse curatorum uidentur desisse inertia ac segnitia non agentium officium. egressis autem urbem dumtaxat agendae rei causa senatus praesto esse lictores iusserat. nobis circumeuntibus riuos fides nostra et auctoritas a principe data pro lictoribus erit.

102 Cum perduxerimus rem ad initium curatorum, non est alienum subiungere qui post Messalam huic officio ad nos usque

[1] praefectis, Philologus, 32, 567.

they go outside of the city in the discharge of their duties, shall have two lictors, three public servants, and an architect for each of them, and the same number of writers, clerks, assistants, and criers as those have who divide the grain among the people; and when they have business within the city on the same duties, they shall content themselves with the same attendants, omitting the lictors; and, further, that the list of servants granted to the water commissioner by this vote of the Senate shall be by them presented to the public treasurer within ten days from its promulgation, and to those whose names shall be thus reported the praetors of the treasury shall give as compensation food by the year, as much as the food commissioners are wont to give, and they shall be authorized to take money for that purpose without prejudice to themselves. Further, there shall be furnished to the commissioners tablets, paper, and everything else necessary for the exercise of their functions. To this effect, the consuls, Q. Aelius and Paulus Fabius, are both requested, or either in default of the other, to consult with the praetors of the treasury in contracting for these supplies.

101. *Further, that the water commissioners, inasmuch as it will take one quarter of the year to fulfil their State duties by attending also to the superintendence of streets and of grain distribution, shall be free from adjudicating in private or State causes.* Although the treasury has continued down to the present to pay for these attendants and servants, they have, as far as appearance goes, ceased to do any work on account of the laziness and negligence of the commissioners, who do not attend to their duties. But when the commissioners went out of the city, provided it was on official business, the lictors had to accompany them according to the commands of the Senate. In my examination of the aqueducts, my self-reliance and the authority given me by the sovereign will stand in place of the lictors.

102. As I have followed the matter down to the introduction of the commissioners, it will not be out of place now to name those who followed Messala[1] in this office up to my incumbency:—

To Messala succeeded, under the consulate of Silius and Plancus, Ateius Capito.[2]

[1] Messala succeeded to Agrippa, under the consulate of Q. Aelius Tubero and Paulus Fabius Maximus, according to Varro, 10 B. C.

[2] A. D. 13.

praefuerint. Messalae successit Planco et Silio cos. Ateius Capito. Capitoni *C. Asinio Pollione* C. Antistio Vetere cos. Tarius Rufus. Tario [et] Seruio Cornelio Cethego L. Visellio Varrone consulibus M. Cocceius Nerua, diui Neruae auus, scientia etiam iuris inlustris. huic successit Fabio Persico L. Vitellio cos. C. Octauius Laenas. Laenati Aquila Iuliano et Nonio Asprenate consulibus M. Porcius Cato. huic successit post mensem Ser. Asinio Celere A. Nonio[1] Quintiliano consulibus A. Didius Gallus. Gallo Q. Veranio et Pompeio Longo cos. Cn. Domitius Afer. Afro Nerone Claudio Caesare IIII et Cosso Cossi f. consulibus L. Piso. Pisoni Verginio Rufo et Memmio Regulo consulibus Petronius Turpilianus. Turpiliano Crasso Frugi et Laecanio Basso consulibus P. Marius. Mario Luccio Telesino et Suetonio Paulino cos. Fonteius Agrippa. Agrippae Silio et Galerio Trachalo cos. Albius Crispus. Crispo Vespasiano III et Cocceio Nerua cos. Pompeius Siluanus. Siluano *Domitiano II* Valerio Messalino consulibus Tampius Flauianus. Flauiano Vespasiano V Tito III consulibus Acilius Auiola. Post quem imperatore Nerua III et Verginio Rufo III consulibus ad nos cura translata est.

103 Nunc quae obseruare curator aquarum debeat et legem senatusque consulta ad instruendum actum pertinentia sub-

[1] Philologus, 6, 378; Nipperdey, *Op.*, 450.

To Capito, under the consulate of C. Asinius Pollio and C. Antistius Vetus, Tarius Rufus.[1]

To Tarius, under the consulate of Servius Cornelius Cethegus and L. Visellius Varro,[2] M. Cocceius Nerva, the grandfather of Divus Nerva, who was also noted as learned in the science of law.

To him succeeded, under the consulate of Fabius Persicus and L. Vitellius,[3] C. Octavius Laenas.

To Laenas, under the consulate of Aquila Julianus and Nonius Asprenas,[4] M. Porcius Cato.

To him succeeded, after a month, under the consulate of Servius Asinius Celer and A. Nonius Quintilianus, A. Didius Gallus.

To Gallus, under the consulate of Q. Veranius and Pompeius Longus,[5] Cn. Domitius Afer.

To Afer, under the fourth consulate of Nero Claudius Caesar, and that of Cossus, the son of Cossus,[6] L. Piso.

To Piso, under the consulate of Verginius Rufus and Memmius Regulus,[7] Petronius Turpilianus.

To Turpilianus, under the consulate of Crassus Frugi and Lecanius Bassus,[8] P. Marius.

To Marius, under the consulate of Lucius Telesinus and Suetonius Paulinus,[9] Fonteius Agrippa.

To Agrippa, under the consulate of Silius and Galerius Trachalus,[10] Albius Crispus.

To Crispus, under the third consulate of Vespasian, and that of Cocceius Nerva,[11] Pompeius Silvanus.

To Silvanus, under the second consulate of Domitian and that of Valerius Messalinus,[12] Tampius Flavianus.

To Flavianus, under the fifth consulate of Vespasian, and the third of Titus,[13] Acilius Aviola.

After whom, under the third consulate of the Emperor Nerva, and the third of Verginius Rufus,[14] the office was transferred to me.

103. I will now set down what the water commissioner must observe, being the laws and Senate enactments which serve for his

[1] A.D. 23.
[2] A. D. 24.
[3] A. D. 34.
[4] A. D. 38.
[5] A. D. 49.
[6] A. D. 60.
[7] A. D. 63.
[8] A. D. 64.
[9] A. D. 66.
[10] A. D. 68.
[11] A. D. 71.
[12] A. D. 73.
[13] A. D. 74.
[14] A. D. 97.

iungam. circa ius ducendae aquae in priuatis obseruanda sunt, ne quis sine litteris Caesaris, id est ne quis aquam publicam non impetratam, et ne quis amplius quam impetrauit ducat. ita enim efficiemus ut modus, quem adquiri diximus, possit ad nouos salientes et ad noua beneficia principis pertinere. in utroque autem magna cura multiplici opponenda fraudi est: sollicite subinde ductus extra urbem circumeundi ad recognoscenda beneficia; idem in castellis et salientibus publicis faciendum, ut sine intermissione diebus *noctibusque* aqua fluat. quod senatus quoque consulto facere curator iubetur, cuius haec
104 uerba sunt: 'Quod Q. Aelius Tubero Paulus Fabius Maximus cos. V. F. de numero publicorum salientium qui in urbe essent intraque aedificia urbi coniuncta, quos M. Agrippa fecisset, Q. F. P. D. E. R. I. C. neque augeri placere nec minui *numerum* publicorum salientium, quos nunc * esse retulerunt ii, quibus negotium a senatu est imperatum ut inspicerent aquas publicas inirentque numerum salientium publicorum. itemque placere curatores aquarum, quos [S. C.] Caesar Augustus ex senatus auctoritate nominauit, dare operam uti salientes publici quam adsiduissime interdiu et noctu aquam in usum populi funderent.' In hoc senatus consulto crediderim adnotandum quod senatus tam augeri quam minui salientium publicorum numerum uetuerit. id factum existimo, quia modus aquarum quae is temporibus in urbem ueniebant, antequam Claudia et Anio nouus perducerentur,
105 maiorem erogationem capere non uidebatur. qui aquam in usus priuatos deducere uolet, impetrare eam debebit et a principe epistulam ad curatorem adferre; curator deinde beneficio Caesaris praestare maturitatem et procuratorem eiusdem officii libertum Caesaris protinus scribere. procuratorem autem primus Ti.

guidance. As concerns the draft of water by private consumers, there is to be noted: *that no one shall draw water without a writing from Caesar, that is, that no one shall draw water from the public supply without a license, and no one shall draw more than has been granted.* By this means, we propose to make it possible that the quantity of water, concerning whose recovery we have spoken, may be distributed to new fountains and may be used for new grants from the sovereign. But in both cases must a great zeal in the service be opposed to manifold forms of fraud. The channels of the aqueducts without the city must be carefully examined, one after the other, to review the granted quantities; the same must be done in case of the delivery tanks and fountains, that the water may flow without interruption, day and night, which the commissioner has been directed to see to, by vote of the Senate, whose words are as follows: —

104. *The consuls, Q. Aelius Tubero and Paulus Fabius Maximus, having made a report upon the number of fountains established by M. Agrippa in the city and adjacent to the city, have inquired of the Senate what it would please to order upon the subject; upon which it has been ordered: That the number of public jet fountains which exist at present, according to the report of those who were ordered by the Senate to examine the public aqueducts and to take account of the number of public jet fountains, shall be neither increased nor diminished. Further, that the water commissioners, who have been appointed by Caesar Augustus, according to vote of the Senate, shall take pains that the public jet fountains may as continuously as possible deliver water for the use of the people day and night.* In this vote of the Senate is to be noted the prohibition by the Senate to increase or diminish the number of public jet fountains. I think this was done because the quantity of water, which at that time came into the city, before Claudia and Anio Novus had been brought in, did not seem to permit of a greater distribution of water.

105. Whoever wishes to draw water for private use must seek for a grant and bring to the commissioner a writing from the sovereign; the commissioner must then immediately carry out the grant of Caesar, and appoint one of Caesar's freedmen as his deputy commissioner. Ti. Claudius appears to have been the first man to

Claudius uidetur admouisse, postquam Anionem nouum et Claudiam induxit. quid contineat epistula, uilicis quoque fieri notum debet, ne quando neglegentiam aut fraudem suam ignorantiae colore defendant. procurator calicem eius moduli, qui fuerit impetratus, adhibitis libratoribus signari cogitet, diligenter intendat mensurarum quas supra diximus modum et positionis notitiam habeat, ne sit in arbitrio libratorum, interdum maioris luminis, interdum minoris pro gratia personarum calicem probare. set nec statim ab hoc liberum subiciendi qualemcumque plumbeam fistulam permittatur arbitrium, uerum eiusdem luminis quo calix signatus est per pedes *quinquaginta*,
106 sicut senatus consulto quod subiectum est cauetur. 'Quod Q. Aelius Tubero Paulus Fabius Maximus cos. V. F. quosdam priuatos ex riuis publicis aquam ducere, Q. D. E. R. F. P. D. E. R. I. C. ne cui priuato aquam ducere ex riuis publicis liceret, utique omnis ii quibus aquae ducendae ius esset datum ex castellis ducerent, animaduerterentque curatores aquarum, quibus locis intra [extra] urbem apte castella priuati facere possent, ex quibus aquam ducerent quam ex castello communem accepissent a curatoribus aquarum. neue cui eorum quibus aqua daretur publica ius esset, intra quinquaginta pedes eius castelli, ex quo aquam ducerent, laxiorem fistulam subicere quam quinariam.' In hoc S. C. dignum adnotatione est, quod aquam non nisi ex castello duci permittit, ne aut riui aut fistulae publicae
107 frequenter lacerentur. ius impetratae aquae neque heredem neque emptorem neque ullum nouum dominum praediorum sequitur. balneis quae publice lauarent priuilegium antiquitus concedebatur, ut semel data aqua perpetuo maneret. sic ex

appoint a deputy commissioner, after he introduced Claudia and Anio Novus. The overseers must also be acquainted with the contents of the writing, so that they cannot excuse themselves for negligence or fraud on the ground of ignorance. The deputy commissioner must attend to having the levellers employed in the business stamp the calix which conforms to the deeded quantity, and for this it will be necessary that he consult what we have above said about the size and position of these ajutages, so as to know how to select them and not to leave to the caprice of the levellers the liberty to adopt a calix of sometimes greater or sometimes smaller interior area, according as they interest themselves in the parties. It must also not be left optional to attach any kind of lead pipe to the ajutages; but there must rather be attached for a length of fifty feet one of the same interior area as that which the ajutage has been certified to have, as has been ordained by a vote of the Senate which follows: —

106. *The consuls, Q. Aelius Tubero and Paulus Fabius Maximus having made a report that some private parties take water directly from the public conduits, have inquired of the Senate what it would please to order upon the subject; upon which it has been ordered:*

It shall not be permitted to any private party to draw water from the public conduits; and all those to whom the right to draw water shall have been granted, shall draw it from the delivery tanks, the water commissioners to direct at what points, within and without the city, private parties may erect suitable delivery tanks for the purpose of drawing water from them, under grants, which in common with others, the water commissioners have located; and no one to whom a right to draw water from the public conduits has been granted, shall have the right to use a larger pipe than a quinaria for a space of fifty feet from the delivery tank out of which he is to draw the water. In this vote of the Senate is to be noted, that it is only permitted to draw water from the delivery tanks, so that the conduits or the public pipes shall not frequently be cut into.

107. The right to granted water does not pass either to the heirs, or to the buyer, or to any new occupant of the land. The public bathing establishments had from old times the privilege that water once granted to them should remain theirs forever. We know this

ueteribus senatus consultis cognoscimus, ex quibus unum subieci
108 nunc omnis aquae cum possessore instauratur beneficium. 'Quod Q. Aelius Tubero Paulus Fabius Maximus cos. V. F. constitui oportere, quo iure *extra* intraque urbem ducerent aquas, quibus adtributae essent, Q. D. E. R. F. P. D. *E. R.* I. *C.* uti usque eo maneret adtributio aquarum, exceptis quae in usum balnearum essent datae aut haustus nomine, quoad idem domini possiderent
109 id solum, in quod accepissent aquam.' Cum uacare aliquae coeperunt aquae, adnuntiatur et in commentarios redigitur, qui respiciuntur ut petitoribus ex uacuis dari possint. has aquas statim intercipere solebant, ut medio tempore uenderent aut possessoribus praediorum aut aliis etiam. humanius [etiam] uisum est principi nostro, ne praedia subito destituerentur, triginta dierum spatium indulgeri, intra quod ii ad quos res pertineret * *. de aqua in praedia sociorum data nihil constitutum inuenio. perinde tamen obseruatur ac iure cautum, ut dum quis ex iis qui communiter impetrauerunt superesset, totus modus praediis adsignatus flueret et tunc demum renouaretur beneficium, cum desisset quisque ex iis quibus datum erat possidere. impetratam aquam alio, quam in ea praedia in quae data erit, aut ex alio castello, quam ex quo epistula principis continebit, duci palamst
110 non oportere; set et mandatis prohibetur. impetrantur autem et eae aquae quae caducae uocantur, id est quae aut ex castellis aut ex manationibus fistularum *, quod beneficium a principibus parcissime tribui solitum. set fraudibus aquariorum obnoxium est, quibus prohibendis quanta cura debeatur, ex capite mandatorum

from old votes of the Senate, of which I give one below. Nowadays every grant of water is renewed to the new owner.

108. *The consuls, Q. Aelius Tubero and Paulus Fabius Maximus having made a report upon the necessity of fixing the extent of the right of those to whom it has been permitted to conduct water both within and without the city, have inquired of the Senate what it would please to order upon the subject; upon which it has been ordered: That a grant of water, with the exception of those which have been granted for the use of bathing establishments, or in the name of Augustus,*[1] *shall remain in force as long as the land remains in the ownership of him to whom the water was granted.*

109. As soon as any water becomes free it is announced, and entered in the records, which are consulted to see what vacant water-rights may be given to petitioners. These waters were formerly cut off immediately, so that between grants they were sold to the occupants of the land, or to outsiders even. It seemed less harsh to our ruler not to deprive estates of water suddenly, but to give thirty days' grace, within which the proper officers could dispose of the water.

I did not find anything set down about the water granted to an estate belonging to a syndicate. Nevertheless the following practice is observed, just as though prescribed by law, *that as long as one of those who have received a grant of water remains among the living, the full amount of granted water shall flow upon the land, and the grant shall be renewable only when every one of those who received it shall have ceased to remain in possession of the property.*

That granted water cannot be carried elsewhere than upon the premises to which it has been made appurtenant, or taken from another delivery tank than the one designated in the writing of the sovereign, is self-evident, but this is also forbidden by ordinance.

110. Those waters also that I have called lapsed, namely, those that come from the leakage out of the cisterns or the pipes, are subject to grants; but these are only rarely given by the sovereign. But they are exposed to thefts by the water-men; and with how much care it should be prohibited may be seen from a paragraph of an ordinance, which I append: —

[1] A probable emendation. The manuscript has *haustus*.

111 manifestum erit quod subieci. . . . 'Caducam neminem uolo ducere nisi qui nostro beneficio aut priorum principum habent. nam necesse est ex castellis aliquam partem aquae effluere, cum hoc pertineat non solum ad urbis nostrae salubritatem, set etiam ad utilitatem cloacarum abluendarum.'

112 Explicitis quae ad ordinationem aquarum priuati usus pertinebant, non ab re est quaedam ex iis, quibus circumscribi saluberrimas constitutiones in ipso actu deprehendimus, exempli causa attingere. ampliores quosdam calices, quam impetrati erant, positos in plerisque castellis inueni et ex iis aliquos ne signatos quidem. quotiens autem signatus calix excedit legitimam mensuram, ambitio procuratoris qui eum signauit detegitur. cum uero ne signatus quidem est, manifesta culpa omnium, maxime accipientis, deprehenditur, deinde uilici. in quibusdam, cum calices legitimae mensurae signati essent, statim amplioris moduli fistulae subiectae fuerunt, unde acciderat ut aqua non per legitimum spatium coercita, sed per breuis angustias expressa facile laxiorem in proximo fistulam inpleret. ideoque illud adhuc, quotiens signatur calix, diligentiae adiciendum est, ut fistulae quoque proxumae per spatium, quod S. C. comprehensum diximus, signentur. ita demum enim uilicus cum scierit non aliter quam signatas con-
113 locari debere, omni carebit excusatione. circa conlocandos quoque calices obseruari oportet ut ad lineam ordinentur nec alterius inferior calix, alterius superior ponatur. inferior plus trahit; superior, quia cursus aquae ab inferiore rapitur, minus ducit. in quorumdam fistulis ne calices quidem positi fuerunt. hae fistulae solutae uocantur et ut aquario libuit, laxantur uel coartantur.
114 adhuc illa aquariorum intolerabilis fraus est: translata in nouum possessorem aqua foramen nouum castello imponunt, uetus relin-

111. *I desire that no one shall draw lapsed water except those who have had permission to do so by grants from me or preceding sovereigns; for there must necessarily be some overflow from the delivery tanks, this being proper not only for the health of our city, but also for use in the flushing of the sewers.*

112. Having now explained those things that relate to the administration of water for the use of private parties, it will not be foreign to the subject to say something, and to give examples, of how we have detected some in the act of contravening these most wholesome ordinances. In a great number of delivery tanks I found ajutages of a larger size than had been granted, and among them some that had not even been stamped. But whenever a stamped ajutage is larger than its legitimate measure it reveals an endeavor to curry favor on the part of the deputy commissioner (*procurator*) who stamped it; but when it is not even stamped it reveals the fault of all, especially of the grantee, also of the overseer. In some of the tanks, though their ajutages were stamped in conformity to their lawful admeasurements, it was found that pipes of a greater diameter were attached to them. As a consequence, the water not being held together for the lawful distance, and being on the contrary forced through the short restricted distance, easily filled the adjoining larger pipe. Care should therefore be taken, as often as an ajutage is stamped, to stamp also the adjoining pipe over the length prescribed by the vote of the Senate which we have quoted. For thus only is the overseer relieved of every excuse he could make, when he knows that none but stamped pipes are allowed to be set in place.

113. In setting ajutages, care must be taken to set them on a level, and not place the one higher and the other lower down. The lower one will take in more; the higher one will suck in less, because the current of water is drawn in by the lower one. To some pipes no ajutages were attached. Such pipes are called uncontrolled, and are expanded or contracted as pleases the watermen.

114. The following method of cheating practised by the watermen is, further, unbearable; when a water-right is transferred to a new owner, they will insert a new ajutage in the delivery tank; the

quunt quo uenalem extrahunt aquam. in primis ergo hoc quoque emendandum curatori crediderim. non enim solum ad ipsarum aquarum custodiam, set etiam ad castelli tutelam pertinet, quod
115 subinde et sine causa foratum uitiatur. etiam ille aquariorum tollendus est reditus, quem uocant puncta. longa ac diuersa sunt spatia, per quae fistulae tota meant urbe latentes sub silice. has conperi per eum qui appellabatur a punctis passim conuulneratas omnibus in transitu negotiationibus praebuisse peculiaribus fistulis aquam, quo efficiebatur ut exiguus modus ad usus publicos perueniret. quantum ex hoc modo aquae surreptum sit, aestimo ex eo quod aliquantum plumbi sublatis eiusmodi ramis redactum est.

116 Superest tutela ductuum, de qua priusquam dicere incipiam, pauca de familia quae huius rei causa parata est explicanda sunt. familiae sunt duae, altera publica, altera Caesaris. publica est antiquior, quam ab Agrippa relictam Augusto et ab eo publicatam diximus; habet homines circiter ducentos quadraginta. Caesaris familiae numerus est quadringentorum sexaginta, quam Claudius
117 cum aquas in urbem perduceret constituit. utraque autem familia in aliquot ministeriorum species diducitur, uilicos, castellarios, circitores, silicarios, tectores aliosque opifices. ex his aliquos extra urbem esse oportet ad ea quae non sunt magnae molitionis, maturum tamen auxilium uidentur exigere. homines in urbe circa castellorum et munerum stationes opera quaeque urgebunt, in primis ad subitos casus, ut ex conpluribus regionibus, in quam necessitas incubuerit, conuerti possit praesidium aquarum abundantium. tam amplum numerum utriusque familiae solitum ambitione aut negligentia praepositorum in priuata opera diduci

old one they leave in the tank and draw water from it which they sell. Most especially, therefore, as I believe, should the commissioner have in mind to stop this; for thus he will maintain not only the measure of the water itself, but also the good condition of the tanks, which get to be leaky when they are so often and unnecessarily tapped into.

115. This mode of gaining money, practised by the water-men, is also to be abolished: the one called "tapping." Far away, and in all directions, run the pipes under the city pavements. I discovered that these pipes were furnishing water by special branches to all whom they passed and who had been able to arrange for it; being bored for that purpose here and there, by the so-called tappers; whence it came, that only a small quantity of water reached the places of public supply. The amount of water gained in consequence of our abatement of this evil, I measure by means of the fact that we have gathered a large quantity of lead by the removal of that kind of branch pipes.

116. It remains to speak of the maintenance of the conduits; but before I say anything about this, a little should be explained about the gangs of slaves employed upon them. There are two of those gangs; one belongs to the State, the other to Caesar. The one belonging to the State is the older, which, as we have said, was left by Agrippa to Augustus, and was by him made over to the State. It numbers about 240 men. The number in Caesar's gang is 460; it was instituted by Claudius at the time he brought his aqueduct into the city.

117. Both gangs are divided into several classes of workmen: overseers, reservoir-keepers, line-walkers, pavers, plasterers, and other workmen; of these, some must be outside the city for purposes which do not require any great amount of work, but demand prompt attention; the men within the city at their stations at the reservoirs and fountains will devote their energies to the several works, especially in case of sudden emergencies, in order that a plentiful supply of water may be turned from several wards of the city to those which are threatened with deprivation. Both these large gangs, which occasionally were taken by exercise of favoritism or by negligence of their foremen for employment on private work, I resolved to bring back to

reuocare ad aliquam disciplinam et publica ministeria ita instituimus, ut pridie quid esset actura dictaremus et quid quoque die
118 egisset actis conprehenderetur. commoda publicae familiae ex aerario dantur, quod inpendium exoneratur uectigalium reditu ad ius aquarum pertinentium. ea constant ex locis aedificiisue quae sunt circa ductus et castella aut munera aut lacus. quem reditum prope sestertiorum ducentorum quinquaginta milium alienatum ac uagum, proximis uero temporibus in Domitiani loculos conuersum iustitia diui Neruae populo restituit, nostra sedulitas ad certam regulam redegit, ut constaret quae essent ad hoc uectigal pertinentia loca. Caesaris familia ex fisco accipit commoda, unde et omne plumbum et omnes impensae ad ductus et castella et lacus pertinentes erogantur.

119 Quoniam quae uidebantur ad familiam pertinere exposuimus, ad tutelam ductuum sicut promiseram diuertemus, rem enixiore cura dignam, cum magnitudinis Romani imperii uel praecipuum sit indicium. multa atque ampla opera subinde dilabuntur, quibus ante succurri debet quam magno auxilio egere incipiant, plerumque tamen prudenti temperamento sustinenda, quia non semper opus aut facere aut ampliare quaerentibus credendum est. ideoque non solum scientia peritorum set et proprio usu curator instructus esse debet, nec suae tantum stationis architectis uti, set plurium aduocare non minus fidem quam subtilitatem, ut aestimet quae repraesentanda, quae differenda sint, et rursus quae per redemptores effici debeant, quae per domesticos artifices.
120 nascuntur opera ex his causis: aut inpotentia possessorum quid corrumpitur aut uetustate aut ui tempestatium aut culpa male

some discipline and to the service of the State, by writing down the day before what each one was to do, and by putting in the records what it had done each day.

118. The wages of the State gang are paid from the State treasury, which expense is made easier for the treasury by the receipt of the rentals from water-rights, which are received from places or buildings situated on and about the conduits, reservoirs, public fountains, or watering basins. This income of nearly 250,000 *sestertii*,[1] formerly lost through loose management, was turned in recent times into the pocket of Domitian; but with a due sense of right the revered (*divus*) Nerva restored it to the people; I took pains to bring it under fixed rules in order that it might be clear what were the places which fell under this tax. The gang of Caesar gets its wages from the emperor's privy purse; from which are also drawn all expenses for lead and for pipes, delivery tanks, and basins.

119. As I have now explained what related to the slave-gangs, I shall now, agreeably to my promise, explain the maintenance of the conduits; a thing which is worthy of special care, as it gives the best testimony to the greatness of the Roman Empire. These numerous and extensive works have a natural tendency to fall into decay, and they must be attended to before they call for large appropriations. As a rule, however, they are only to be taken hold of after due consideration; because those who urge the construction or extension of works cannot always be trusted. The water commissioner therefore ought not only to be provided with advisers, but ought also to be armed with self-acquired practical experience of his own. He must consult not only the builders in the employ of the office, but must seek aid from the trustworthy and thorough knowledge of outsiders, in order to judge what must be taken in hand forthwith, and what postponed; again, what is to be carried on by public contractors and what done by his own regular workmen.

120. The necessity of repairs arises from the following reasons: by lawlessness of the owners of fields traversed, by age, by the weather, or by poor workmanship in the original construction, which has happened frequently in the case of recent work.

[1] Equivalent at this time to about $10,000 or $12,000 coin.

121 facti operis, quod saepius accidit in recentibus. fere aut uetustate aut ui *tempestatium eae* partes ductuum laborant quae arcuationibus sustinentur aut montium lateribus adplicatae sunt, et ex arcuationibus eae quae per flumen traiciuntur. ideoque haec opera sollicita festinatione explicanda sunt. minus iniuriae subiacent subterranea nec gelicidiis nec caloribus exposita. uitia autem eiusmodi sunt, ut aut non interpellato cursu subueniatur eis, aut emendari nisi auerso non possint, sicut ea quae in ipso alueo
122 fieri necesse est. haec duplici ex causa nascuntur: aut enim limo concrescente, qui interdum in crustam indurescit, iter aquae coartatur, aut tectoria corrumpuntur, unde fiunt manationes quibus necesse est latera riuorum et substructiones uitiari. pilae quoque ipsae tofo extructae sub tam magno onere labuntur. refici quae circa alueos riuorum sunt aestate non debent, ne intermittatur usus tempore quo praecipue desideratur, set uere uel autumno et maxima cum festinatione, ut scilicet ante praeparatis omnibus quam paucissimis diebus riui cessent. neminem fugit, per singulos ductus hoc esse faciendum, ne si plures pariter auer-
123 tantur, desit aqua ciuitati. ea quae non interpellato aquae cursu effici debent, maxime structura constant, quam et suis temporibus et fidelem fieri oportet. idoneum structurae tempus est a calendis Aprilibus in calendas Nouembres ita ut optimum sit intermittere eam partem aestatis quae nimiis caloribus incandescit, quia temperamento caeli opus est, ut ex[1] commodo structura conbibat et in unitatem conroboretur; non minus autem sol acrior quam gelatio praecipit materiam. nec ullum opus diligentiorem poscit curam quam quod aquae obstaturum est; fides itaque eius per singula secundum legem notam omnibus set a paucis

[1] Hermes, 6, 249.

124 obseruatam exigenda est. illut nulli dubium esse crediderim, proximos ductus, id est qui a *septimo* miliario lapide quadrato consistunt, maxime custodiendos, quoniam et amplissimi operis sunt et plures aquas singuli sustinent. quos si necesse fuerit interrumpere, maiorem partem aquarum urbis destituent. remedia tamen sunt et huius difficultatis: opus inchoatum excitatur ad libram deficientis, alueus uero plumbatis canalibus per spatium interrupti ductus rursus continuatur. porro quoniam fere omnes specus per priuatorum agros derecti erant et difficilis uidebatur futurae impensae praeparatio, nisi et aliqua iuris constitutione succurreretur, simul ne accessu ad reficiendos riuos redemptores a possessoribus prohiberentur, S. C. factum est quod subieci.

125 'Quod Q. Aelius Tubero Paulus Fabius Maximus cos. V. F. de riuis, specibus, fornicibus aquae Iuliae, Marciae, Appiae, Tepulae, Anienis reficiendis, Q. D. E. R. F. P. D. E. R. I. C. uti cum ii riui, *specus*, fornices, quos Augustus Caesar se refecturum impensa sua pollicitus senatui est, reficerentur, ex agris priuatorum terra, limus, lapides, testa, harena, ligna ceteraque quibus ad eam rem opus esset, unde quaeque eorum proxime sine iniuria priuatorum tolli, sumi, portari possint, uiri *boni* arbitratu aestimata darentur, tollerentur, sumerentur, exportarentur; et ad eas res omnes exportandas earumque rerum reficiendarum causa, quotiens opus esset, per agros priuatorum sine iniuria eorum itinera, actus

126 paterent, darentur.' Plerumque autem uitia oriuntur ex inpotentia possessorum, qui pluribus riuos uiolant. primum enim spatia, quae circa ductus aquarum ex S. C. uacare debent, aut aedificiis aut arboribus occupant. arbores magis nocent, quarum

124. No one probably will doubt that the greatest care should be taken with the aqueducts nearest to the city, namely: those within the seventh mile-stone, which consist entirely of block-stone masonry; because, in the first place, they are of such great extent, and because each one carries several conduits; for should it once be necessary to interrupt these, the greater part of the water of the city would be diverted. But there are methods for meeting even these difficulties; a foundation is built up to the level of the defective conduit, and the channel is continued over the length of the destroyed portion in troughs made of lead. Inasmuch as all the aqueducts were built through the fields of private parties and it seemed difficult to provide for future works of construction without the help of some constituted law; also, in order that proprietors might not be able to prohibit the contractors from access to the conduits needing to be repaired, a vote of the Senate was passed, which I give below: —

125. *The consuls, Q. Aelius Tubero and Paulus Fabius Maximus, having made a report relating to the restoration of the canals, conduits, and arches of Julia, Marcia, Appia, Tepula, and Anio, have inquired of the Senate what it would please to order upon the subject; upon which it has been ordered: That when the canals, the conduits, and the arches, which Augustus Caesar has promised to the Senate should be repaired at his cost, shall be repaired, the earth, clay, stone, potsherds, sand, wood, &c. and whatever is necessary for the work in hand, and, from whatever source each of these things may most conveniently and without prejudice to private parties be brought, obtained, taken, they shall be brought, obtained, and taken upon the estimate of a good man as arbitrator; and that rights of way through the lands of private parties without injury to them shall remain open and be permitted, as often as it is necessary for the transportation of all these things for the purposes of repairing these works.*

126. But generally damages occur by reason of the lawlessness of private owners, who injure the canals in numerous ways. In the first place, they occupy the space around the aqueducts, which according to the vote of the Senate should remain open, with structures or with trees. The trees do the most damage, because their roots burst asunder the top coverings as well as the sides; they also lay out

radicibus concamerationes et latera soluuntur. dein uicinales uias agrestesque per ipsas formas derigunt. nouissime aditus ad tutelam praecludunt. quae omnia S. C. quod subieci prouisa sunt.

127 'Quod Q. Aelius Tubero Paulus Fabius Maximus cos. V. F. aquarum, quae in urbem uenirent, itinera occupari monumentis et aedificiis et arboribus conseri, Q. F. P. D. E. R. I. C. cum ad reficiendos riuos specusque * * per quae [et] opera publica corrumpantur, placere circa fontes et fornices et muros utraque ex parte quinos denos pedes patere, et circa riuos qui sub terra essent et specus intra urbem et [extra] urbi continentia aedificia utraque ex parte quinos pedes uacuos relinqui ita ut neque monumentum in is locis neque aedificium post hoc tempus ponere neque conserere arbores liceret, sique nunc essent arbores intra id spatium, exciderentur praeterquam si quae uillae continentes et inclusae aedificiis essent. si quis aduersus ea conmiserit, in singulas res poena H-S dena milia essent, ex quibus pars dimidia praemium accusatori daretur, cuius opera maxime conuictus esset qui aduersus hoc S. C. conmisisset, pars autem dimidia in aerarium redigeretur. deque ea re iudicarent cognoscerentque cura-

128 tores aquarum.' Posset hoc S. C. aequissimum uideri, etiam *si* ex re tantum publicae utilitate ea spatia uindicarentur. multo magis autem maiores nostri admirabili aequitate ne ea quidem eripuerunt priuatis quae ad modum publicum pertinebant, set cum aquas perducerent, si difficilior possessor in parte uendunda fuerat, pro toto agro pecuniam intulerunt et post determinata necessaria loca rursus eum agrum uendiderunt, ut in suis finibus proprium ius res publica priuatique haberent. plerique tamen non contenti occupasse fines ipsis ductibus manus adtulerunt per

neighborhood roads and field roads over the aqueducts; finally, they hinder the repair of the works by stopping access to them. All this has been provided for in the vote of the Senate, which follows: —

127. *The consuls Q. Aelius Tubero and Paulus Fabius Maximus having made a report that the rights of way of the aqueducts coming to the city are occupied with tombs and edifices and planted with trees, have inquired of the Senate what it would please to order upon the subject; upon which it has been ordered: That for the purposes of repairing the channels and masonry conduits, and generally all public structures that might be destroyed, it is decreed that there shall be kept a space clear and unoccupied of fifteen feet on each side of the springs, arches, and walls; and that about the subterranean conduits and channels, both within the city and adjoining the city, if there be buildings near, there shall be a vacant space of five feet; and it shall not be permitted to erect a tomb at these places after this time, nor any structures, nor to plant trees. If there be any trees within this space at the present time they shall be taken out by the roots except when they are connected with country seats or enclosed in buildings. Whoever shall contravene these provisions shall pay the penalty, for each contravention, 10,000 sestertii, of which one half shall be given as a reward to the accuser through whose especial endeavors the violator of this vote of the Senate shall have been convicted; the other half shall be paid into the public treasury. About these matters the water commissioners shall judge and take cognizance.*[1]

128. This vote of the Senate would appear perfectly just even if this ground were claimed solely in view of the public advantage; the more so because our forefathers with their admirable equity did not take away even those lands from private parties which were necessary adjuncts to the lands requisite for the public needs, but in the construction of the waterworks paid for the whole field in those cases in which the proprietors made any difficulty in the sale of a portion of the field, and after enclosing the needed portion again sold the fields, with the understanding that each one within his boundaries, the public as well as private parties, should have his legal rights. But many have not been content to assume control up to the boundaries, but have laid hands on the aqueducts by diverting, here and there,

[1] Bruns, *Fontes*, page 185, S. C. *de aquaeductibus.* B. C. 11.

suffossa latera passim cursus *aquarum* * *tam ei qui* ius aquarum impetratum habent, quam ii qui quantulicumque beneficii occasione ad expugnandos riuos abutuntur. quid porro fieret, si non uniuersa ista diligentissima lege prohiberentur poenaque non mediocris contumacibus intentaretur? quare subscripsi uerba
129 legis. 'T. Quintius Crispinus consul . . . populum iure rogauit populusque iure sciuit in foro pro rostris aedis diui Iulii pr. *k.* Iulias. tribus Sergia principium fuit. pro tribu Sex. * L. f. Varro *primus sciuit.* quicumque post hanc legem rogatam riuos, specus, fornices, fistulas, tubulos, castella, lacus aquarum publicarum, quae ad urbem ducuntur, sceins dolo malo forauerit, ruperit, foranda rumpendaue curauerit peioraue fecerit, quo minus eae aquae earumue quae pars in urbem Romam ire, cadere, fluere, peruenire, duci *possit*, quoue minus in urbe Roma et in iis locis, *aedificiis*, quae *loca*, aedificia urbi continentia sunt, erunt, in is hortis, praediis, locis, quorum hortorum, praediorum, locorum dominis possessoribusue aqua data uel adtributa est uel erit, saliat, distribuatur, diuidatur, in castella, lacus inmittatur, is populo Romano HS centum milia dare damnas esto. et qui D. M. quid eorum ita fecerit, id omne sarcire, reficere, restituere, aedificare, ponere et celere demolire damnas esto sine dolo malo atque omnia ita ut ** quicumque curator aquarum est, erit, si curator aquarum nemo erit, tum is praetor qui inter ciues et peregrinos ius dicet, multa, pignoribus cogito, coercito, eique curatori aut si curator non erit, tum ei praetori eo nomine cogendi, coercendi, multae dicendae siue pignoris capiendi ius potestasque esto. si quid eorum seruus fecerit, dominus eius HS centum milia populo *R.* D. D. E. si qui *locus* circa riuos, specus, fornices, fistulas, tubulos, castella, lacus aquarum publicarum, quae ad urbem Romam ducuntur et ducentur, terminatus est et erit, ne quis in eo loco post hanc

some of the water to their own use through the side walls of the punctured channels; this having been done not only by those who have a right to draw water, but also by those who misuse the least favor given them, by attacking the walls of the conduits. What more would not be done, were they not held in restraint by a carefully drawn law, and were not the transgressors threatened with a serious penalty? The words of the law are given below: —

129. *The consul T. Quinctius Crispinus duly called together the people, and the people duly passed a vote in the Forum, near the rostra of the temple of Divus Julius the day preceding the Ides of July. The tribe Sergia, which was to vote first, chose Sextus Varro, the son of Lucius Varro, to propose as follows: Whoever, after the promulgation of this law, shall maliciously and knowingly pierce, break, or attempt to pierce or break, the canals, conduits, arches, pipes, drains, reservoirs, basins of the public water supply, or who shall do damage with intent to diminish the water-courses, or portions of them, so as to prevent them from going, spreading, flowing, reaching, being conducted into the City of Rome; or so as to prevent the flow, distribution, allotment, discharge into delivery tanks or basins of any water in buildings at Rome and in those appurtenant to the city, or in the gardens, the properties, or estates of those to whom the water is now or in future shall be given or granted, shall be condemned to pay a fine of 100,000 sestertii*[1] *to the Roman people; and in addition, whoever shall have knowingly and maliciously done any of these things, shall be condemned to repair, restore, re-establish, reconstruct, replace, what he has deranged, and quickly demolish what he has built, — all in good faith. Further, whoever is or shall be water commissioner, or in default of such officer, whoever is praetor charged to judge between the citizens and strangers, is authorized to fine, bind over by bail, or constrain. The right and power to fine, to bind over by bail, to punish or constrain, shall belong to every water commissioner, or in his absence to the praetor. If a slave shall do any such damage, his master is to pay 100,000 sestertii to the people. If any enclosure has been made or shall be made near the canals, conduits, arches, pipes, drains, reservoirs, or basins, of the public waters, which now are or in future shall be conducted into the City of*

[1] About $4,600 of coin.

legem rogatam quid obponito, molito, obsaepito, figito, statuito, ponito, conlocato, arato, serito, neue in eum quid immittito, praeterquam eorum faciendorum, reponendorum causa, [praeterquam] quae hac lege licebit, oportebit. qui aduersus ea quid fecerit, [et aduersus eum] siremps lex, ius causaque omnium rerum omnibusque esto, atque uti esset esseue oporteret, si is aduersus hanc legem riuum, specum rupisset forassetue. quo minus in eo loco pascere, herbam, fenum secare, sentes *tollere liceat, eius hac lege nihilum rogatur.*[1] curatores aquarum, qui nunc sunt quique erunt, *faciunto ut in eo loco, qui locus*[1] circa fontes et fornices et muros et riuos et specus terminatus est, arbores, uites, uepres, sentes, ripae, maceria, salicta, harundineta tollantur, excidantur, effodiantur, excodicentur, uti quod recte factum esse uolent; eoque nomine iis pignoris capio, multae dictio coercitioque esto; idque iis sine fraude sua facere liceat, ius potestasque esto. quo minus uites, arbores, quae uillis, aedificiis maceriisue inclusae sunt, maceriae, quas curatores aquarum causa cognita ne demolirentur dominis permiserunt, quibus inscripta insculptaque essent ipsorum qui permisissent curatorum nomina, maneant, hac lege nihilum rogator. quo minus ex iis fontibus, riuis, specibus, fornicibus aquam sumere, aurire iis, quibuscumque curatores aquarum permiserunt, permiserint, praeterquam rota, calice, machina liceat, dum ne qui puteus neque
130 foramen nouum fiat, eius hac lege nihilum rogator.' Vtilissimae legis contemptores non negauerim dignos poena quae intenditur, set neglegentia longi temporis deceptos leniter reuocari oportuit. itaque sedulo laborauimus ut quantum in nobis fuit, etiam ignorarentur qui errauerant. is uero qui admoniti ad indulgentiam imperatoris decucurrerunt, possumus uideri causa impetrati beneficii fuisse. in reliquom uero opto ne executio legis necessaria sit, cum officii fidem etiam *per* offensas tueri praestiterit.

[1] Ephem., *Hist. juris*, 15, 301.

Rome, no one shall, after the passage of this law, put in the way, construct, obstruct, plant, establish, set up, place, plough, sow anything, or admit anything in that space unless for the purpose of doing those things and making those repairs which shall be lawful and obligatory under this law. If any one contravenes these provisions, against him shall apply and ought to apply the same law, the same statute, and the same procedure in every particular as against him who in contravention of this statute shall cut or pierce the channel of an aqueduct. Nothing in this law shall revoke the privilege of pasturing cattle, cutting grass or hay, or gathering brambles. The water commissioners, present or future, in any place which either now is or in future shall be enclosed about any springs, arches, walls, canals, or conduits, are authorized to remove, pull out, uproot any trees, vines, bushes, hedges, banks, fences, willows, or reeds, while remaining within the equity of the text of the law, which gives them the right and the power to fine, to bind over by bail, or order personal constraint. As for the vines and trees enclosed in bounds or within structures or fences, nothing is enacted by this law to prevent their remaining, if the water commissioners have decided that they are not to be demolished, and if the names of the commissioners who have so ordered be inscribed and engraved thereon.

Nor shall anything in this law revoke the permits that have been given by the water commissioners to any one, to take or draw water from springs, canals, conduits, vaults, provided that neither wheel, calix, nor machine be used, that no well be dug, and that no new tap be made.

130. I should call the transgressor of so beneficent a law not unworthy of the threatened punishment. But those who have lived in an atmosphere of delusion, and to whom a violation of the law had become second nature in the course of time, had to be brought back to the right way of thinking by gentle means. I therefore endeavored with diligence that as far as possible the erring ones should remain unknown. Those who sought the Emperor's pardon, after due warning received, may thank me for the pardon granted. But for the future, I would wish that it might not be necessary to invoke the law, for it will be necessary to maintain the honor of my office even at the risk of giving offence.

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EXPLANATORY CHAPTERS

ON

THE TWO BOOKS ON THE WATER SUPPLY OF THE CITY OF ROME OF

(SEXTUS) JULIUS FRONTINUS

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THE TWO BOOKS ON THE WATER SUPPLY OF THE CITY OF ROME OF

(SEXTUS) JULIUS FRONTINUS

CHAPTER I

SOME ACCOUNT OF THE LIFE AND WORKS OF SEXTUS JULIUS FRONTINUS

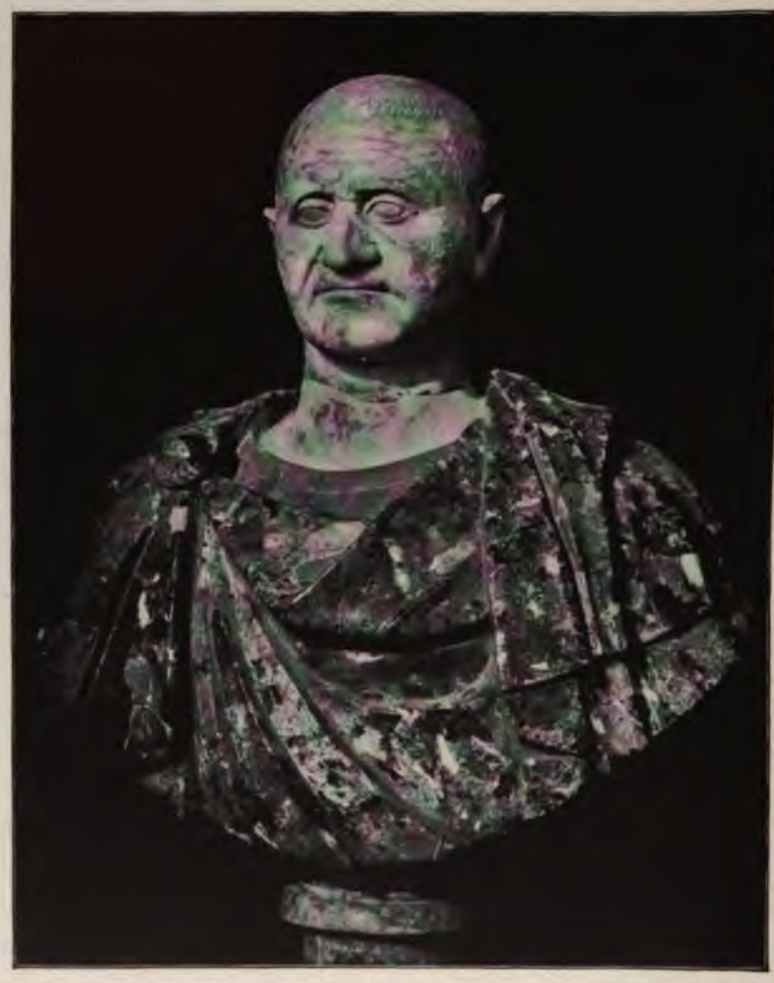
About A. D. 35 to about 103 or 104

> Impensa monumenti supervacua est; memoria nostri durabit, si vita meruimus.
>
> PLINY, *Epist.* viii. 19.
>
> The expense of a monument is superfluous; remembrance will endure, if the life shall have merited it.
>
> *Frontinus' own words, quoted by Pliny.*
>
> Imago animi sermo est; qualis vir, talis oratio.
>
> PS.-SENECA, *De moribus*, 72, 73.
>
> Speech is the image of the soul; as is the man, so will his language be.

THE sources of our knowledge concerning the man Frontinus are naturally few, disjointed, and largely indefinite. Nevertheless, a fair idea of his personality can be gained from references to him made by his contemporaries and by succeeding generations, supplemented by his own writings.

He is first mentioned in history, A. D. 70, by Tacitus, "Histories," Book IV., chap. xxxix: "On the Calends of January (A. D. 70) in the Senate convened by Julius Frontinus, the city praetor, a vote of thanks was passed. . . . Upon the resignation of Frontinus, Caesar Domitian received the praetorship." This was done, says Suetonius ("Life of Domitian," chap. i.), so that Domitian as praetor could also act as consul in the absence from the city of his father, the then Emperor

Vespasian, and of Vespasian's other son, Titus, — absent on the conquest of Judaea, — who were consuls that year. One way of fixing the date of Frontinus' birth is from this fact of his having been



EMPEROR CAESAR *VESPASIANUS* AUGUSTUS.[1]
Reigned A. D. 69–79.

praetor in the year 70, being then presumably thirty-four or thirty-five years old; that is, born A. D. 36 or 35. As will be seen later on, it is necessary to assume that he was born not much earlier, so as to enable him to have gone to the wars with Trajan while not much over sixty years old.

[1] Ancient work of art. In the Vatican Museum.

Others have argued from a statement of Cicero, made one hundred years previously ("Fifth Philippic," 17, 48) as follows: "Did not the Macedonian Alexander, having begun to perform mighty deeds from his earliest youth, die when he was only in his thirty-third year? And that age is ten years less than that fixed by our laws for a man to be eligible for the consulship;" and as Frontinus was made consul in 73 or 74, that he was then forty-two years old, or was born in 31 or 32. The force of this argument is destroyed, however, by considering that laws and customs change. Only thirty-seven years after Cicero's death Augustus was already making his grandson Gaius, then fourteen years old, a consul, with the proviso that he was not to serve until he was nineteen, all of which duly came to pass.

On the other hand, some writers think Frontinus was born as late as A. D. 40; so that, under all these circumstances, I have assumed that Frontinus was born about A. D. 35, and this assumption is in all probaability not more than five years out of the way. As a mathematician or engineer would say, Frontinus was born A. D. 35 ± 5.

At the age of thirty-five, therefore, he was a city praetor (*praetor urbanus*) in the city of Rome. This was a highly honorable office, generally held in Frontinus' time by patricians, and endowed with both judicial and executive functions. This office, still higher offices subsequently held by Frontinus, such as the consulship three times, the governorship of Britain, and, as he himself points out, his holding the office of water commissioner, "from olden time exercised by the most distinguished citizens,"[1]—all these things mark him as sprung from a patrician or noble family, which is also indicated by the name Julius.

The place of his birth is not known with certainty; but as a treatise of one Julius Frontinus Siculus on Metes and Bounds is classed with his other writings, it is assumed that he was so called in this manuscript because he was born in Sicily, unless, indeed, this could be the improbable case of a writer on a class of subjects on which our Frontinus wrote who happened to be named Julius Frontinus Siculus.

It had been part of the policy of Vespasian, on becoming emperor, to give to able and distinguished men from the provinces positions in

[1] *De Aquis*, 1.

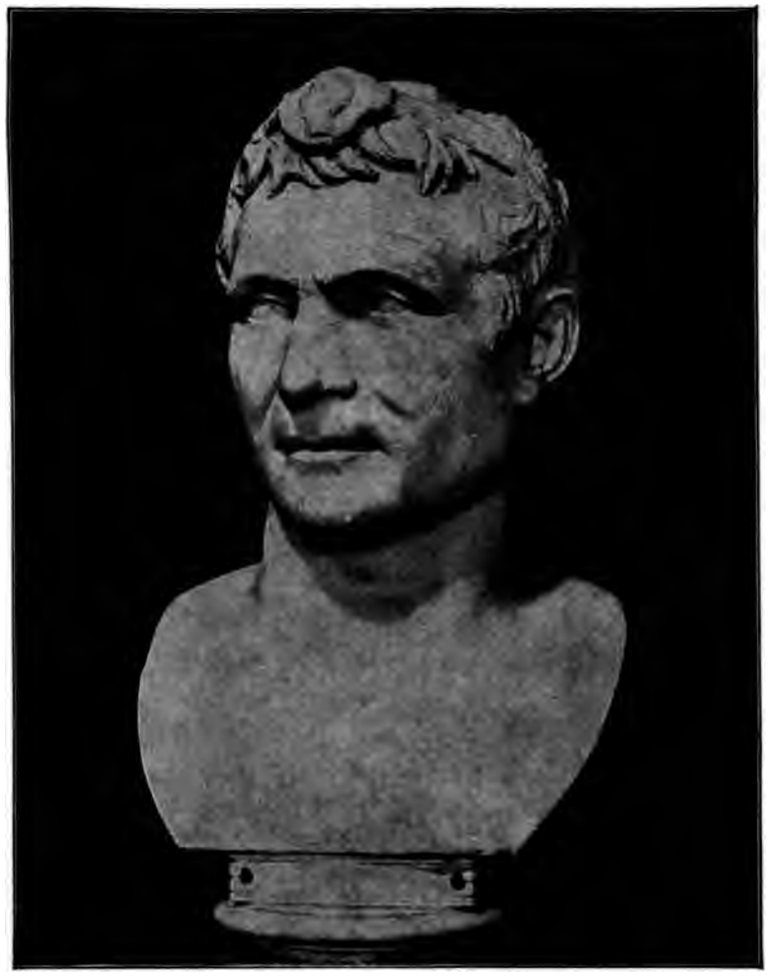
the Roman government. Frontinus' writings on surveying, so far as we have knowledge of them, betray the teaching of the Alexandrian school of mathematicians, especially of Hero of Alexandria. A supposition

EMPEROR *TITUS* VESPASIANUS CAESAR AUGUSTUS.[1]
Reigned A. D. 71 - 81.

that Frontinus, educated in Alexandria, had distinguished himself in Sicily by his writings and services as a surveyor, and had been thereupon called to Rome and been made *praetor urbanus* and later *consul suffectus* at the instance of Vespasian, would therefore be an entirely reasonable one.

[1] Ancient work of art. In the Vatican Museum.

The date of Frontinus' death is approximately determined from the fact that Pliny succeeded him in the office of *augur*, which was a life appointment; and Pliny's letters referring to this succession[1] have



EMPEROR CAESAR *AUGUSTUS.*[2]
Reigned 31 B. C. — A. D. 14.

caused students to fix upon A. D. 103 or 104 as the date of Frontinus' death, he being then about sixty-nine years of age.

We now ask ourselves the question, What was the state of the world, and particularly of the Roman world, during these years A. D. 35 to 104? Whereabouts on the shores of the stream of time are these

[1] Pliny, *Epist.*, iv, 8, 3; and 10, 13, his application to Trajan to be appointed augur.
[2] Ancient work of art. In the Vatican Museum.

years located? Appealing to my engineering friends for a justification of the method, I have drawn a diagram representing the lives of many well-known men, — of some who lived before Frontinus, of some of his contemporaries, and of some who lived after him.

Abscissae represent years of the world's history. Ordinates represent years of the lives of individuals. A glance will show the contemporaries of each man named, on any one date, and the age of each one at that time. On the top of the diagram are marked the reigns of the emperors from Augustus to Marcus Aurelius, both inclusive. On the bottom of the diagram are noted a few events that occurred eighteen hundred years later than those noted in the diagram. They may serve as a sort of scale by which to measure the bearing of events upon each other that occurred eighteen hundred years earlier. Thus, the time of Julius Caesar was no nearer to Frontinus than that of Queen Anne or of the French and Indian War is to us; and Frontinus had no more premonition of the decline and fall of the Roman Empire (say A. D. 330) than we have of what is going to happen in A. D. 2122. His manhood was passed during the time of Rome's greatness under the emperors; and, though he presumably suffered under the later years of Domitian, he on the other hand benefited by the wise and, for those ages, humane rule of Vespasian, Nerva, and Trajan.

About A. D. 74 (the latest determinations make it 73), Frontinus was made *consul suffectus*, as has already been noted. We know that he was a consul from the preface to Aelian's (211–235 or 260) "Treatise on the Art of Arranging Armies in Battle," where he is called a man of consular dignity; also from inscriptions that have come down to us. He was consul three times, or, as the inscriptions have it, "Cos. III."

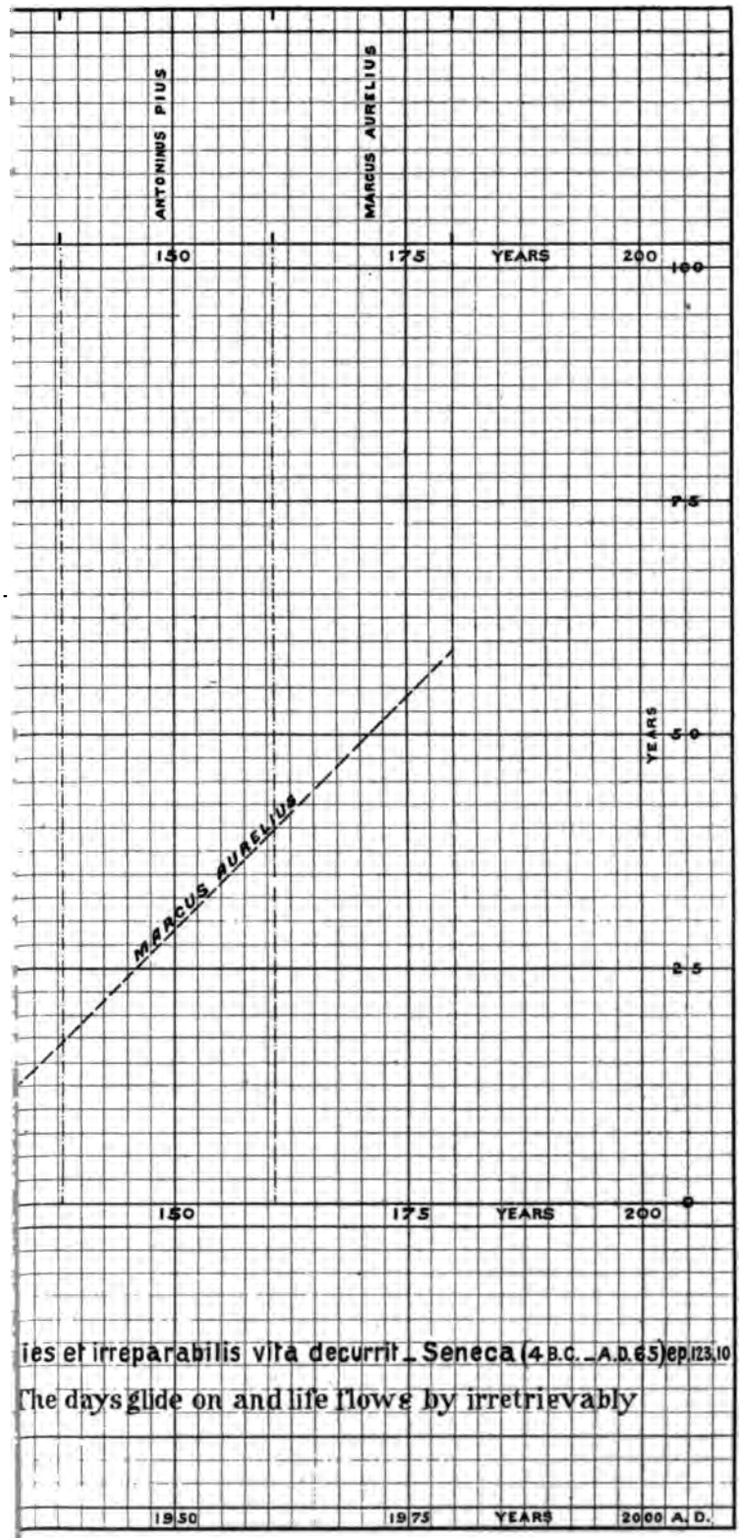
Concerning Cos. I., see Nipperdey ("Opuscula," p. 520, written in 1872), who fixes the date as being A. D. 73.

Cos. II., — see Martial, the Roman poet (43–104), x. 48,[1] — was in 98; C. I. L., iii. p. 862; also J. d. Alterthumsfreunde, etc., 72, 30.

Cos. III., was in 100, as per Or.-Henzen, 6545; Wilmanns, 1194a; and C. I. L., viii. 7066.

He must have been of the consular rank to be eligible for the governorship or proconsulship of Britain, an office to which he was

[1] Preparations for a banquet. "For dessert I will give ripe fruits; wine from a Nomentan flagon which was filled in the second consulship of Frontinus."



ies et irreparabilis vita decurrit. Seneca (4 B.C.–A.D. 65) ep. 123.10

The days glide on and life flows by irretrievably

appointed about A. D. 76 to 78, succeeding Cerealis, a noted Roman general. Here we are on tolerably certain ground, by reason of Chapter 17 of Tacitus, in his "Life of Agricola." We should be still more certain, did the authorities agree upon the meaning of what Tacitus is held to say. This happens to be a case where the original words of the author (Tacitus) are hopelessly lost in a maze of faulty transcription and other errors, making a correct translation impossible. One translation is this: "Now, the conduct of Cerealis was such that it might well obscure the fame of his successor; but Julius Frontinus, a great man, sustained the full glory of Cerealis at every opportunity, and subdued the powerful and warlike people of South Wales, in whom he had to surmount, not only a determined courage, but also the difficulties of their country." Others make out of this sentence, in the original,[1] an unnamed successor to Cerealis, and predecessor of Frontinus, who failed to keep up the reputation of Cerealis, where Frontinus succeeded.

However that may have been, Cerealis, the predecessor, or one of the predecessors, of Frontinus, is held to have gone to Britain in 71, and Agricola, the successor of Frontinus, in 78.[2]

Passing now to Britain, and more especially to Glamorganshire, to the country of the Silures, numerous traces of Frontinus are yet to be found.[3] Referring to Charlston Rock, Camden says: "And here probably commenced the Julia Strata, vestiges of a Roman causeway having been discovered at the neighboring village of Creek, in the road to Caerwent. At the distance of five miles from Chepstow, and three from Sudbrook, in nearly a western direction, the road made on the Via Julia crosses a considerable station, or camp, longitudinally and at right angles. This camp holds a little village called Caerwent.

[1] Cum Cerealis quidem alterius successoris curam famamque obruisset: sustinuit quoque molem Julius Frontinus, vir magnus, quantum licebat, validamque et pugnacem Silurum gentem armis subegit, super virtutem hostium, locorum quoque difficultates, eluctatus. — TACITUS, *Vit. Agr.* 17.

A great deal has been written as to the meaning of "quantum licebat," one guess being that it refers to Frontinus having been hindered by orders from Vespasian to be very economical in the conduct of his campaigns, and not to carry the war beyond certain lines.

[2] A learned article on the dates of all the Roman governors of Britain in *Rheinisches Museum*. xii. 52, by Hübner. See also Nipperdey, *Opuscula*.

[3] Williams' *History of Monmouthshire*, ii. 38. Also Camden's *Britannia*, Gough's additions; and Harris, in *Archaeologia*.

The choice of Caerwent as a camp by the Roman general was judicious, either for the attack of Caer-osc, the capital of Siluria, or to cover it when in his possession. The camp was formed on an eminence greatly elevated, with a small river at its base, commanding views of great extent and the principal communications of the country. The foundations of the Roman wall are discernible at this time (1796)."

Caerwent is supposed to be derived from *Venta Silurum*, "caer" being the Welsh for "city," and the Via, or Strata, Julia is thought to have been named after Frontinus.

In A. D. 78, then, Frontinus returned to Rome from Britain, and the Emperor Vespasian, whom he had been serving, died the following year. Vespasian was succeeded by his son Titus, who reigned only a little over two years; and Titus, by his own brother, Domitian.

In Frontinus' book called "Strategematics," composed of three books, to which has been added, some say by another hand, a fourth book, called "Strategica," Frontinus is directly mentioned only once, in iv. 3, 14. But it has also been thought that four mentions of the Emperor Domitian (i. 1, 8; i. 3, 10; ii. 2, 23; and ii. 11, 7) are cases of self-effacement on the part of Frontinus, and that the acts there ascribed to the emperor were in fact done by his general, Frontinus. Similar courtier-like language is to be found in the "De Aquis," so that it may with show of reason be supposed that Frontinus was a soldier both before and after his governorship of Britain. "Strategematics," i. 5, 26, some read as though it referred to Frontinus' experience in his campaign against the Silures in Britain. In 84 Domitian returned from his German wars against the Catti, inhabiting what is now Nassau, Hesse, and a part of Westphalia; and as he is called "Germanicus" in Frontinus' "Strategematics," this gives not earlier than 84 as the date of this book. Gundermann, in Supplementary Vol. XVI., "Neue Jahrbücher f. Philologie," etc., 1888, fixes on 88–95 as the date when "Strategematics" was written, and thinks another writer added "Strategica," or Book IV. of the former work, early in the second century. Frontinus' "Treatise on the Art of War," which has been lost, may have been written immediately after his return from Britain, in 78. Both are probably alluded to, and perhaps his writings

on surveying also, in "De Aquis," 2, where he says, "But my other commentaries were inspired by my own hard-earned practice and experience, and were intended for the benefit of my successors." And

EMPEROR *DOMITIANUS* CAESAR AUGUSTUS.[1]
Reigned A. D. 81 - 96.

his "Art of War" is also spoken of by himself in his preface to "Strategematics," as follows: "Of those who have attached themselves to military science, I alone have ventured to reduce its rules to system; and it has been admitted that I have not failed in that object as far as it was within any ordinary power. I deem it, however, necessary to

[1] Ancient work of art. In the Vatican Museum.

the completion of my plan to form a small collection of those shrewd, inventive, and ever active principles of military policy which the Greeks express by the single but comprehensive term, 'Strategematica,'" etc.

We have scant information concerning nigh twenty years of Frontinus' life, A. D. 78–97 (forty-three to sixty-two of his own life), which appear to have been taken up with going to the Cattian war in company with Domitian in 83, as above referred to; with his duties as augur; in retirement on account of Domitian's excesses and tyranny, and while in this retirement presumably in literary work.

It is of these days of literary leisure, in a delightful environment, that Martial speaks in Book X., Ep. 58, in an epigram addressed to Frontinus, excusing himself for having neglected to pay his respects: "Whilst I frequented, Frontinus, the calm retreats of Anxur[1] on the sea, and the neighboring Baiae,[2] with its villas on the shore, the groves free from the troublesome *cicadae* (grasshoppers or katydids) in the heats of July, and the fresh water lakes, I was then at leisure, in company with you, to cultivate the learned muses; but now mighty Rome exhausts me. Here, when is a day my own? I am tossed about in the vortex of the city, and my life is wasted in laborious nothingness. Meantime I cultivate some wretched acres of a suburban farm, and keep my homestead near thy temple, O sacred Romulus. But love is not testified solely by day and night attendance on a patron; nor does such waste of time become a poet. By the sacred muses and by all the gods I swear that I love thee, though I fail to exercise the officiousness of a mere client."

Under the circumstances that have been detailed, and amidst such scenes, having found it distasteful, if not dangerous to his life, or at least his welfare, to remain in Rome under the tyranny of Domitian's later years,[3] Frontinus wrote his "Stratagems of War," a collection of

[1] Statius, *Silvae* (40–96), v, 3, 81. The modern Terracina.

[2] A well-known Roman seashore resort, mentioned by Virgil, Horace, Propertius, and others. For example, Martial, x. 51.

[3] We get some contemporary opinions of those years under Domitian, from Pliny's letters. In v. 15 he says, "Since virtue is no longer as formerly [under Domitian or Nero] exposed to the most cruel dangers, but advanced to the noblest dignities."

In viii. 13 he calls the succession of Nerva "the first restoration of liberty;" and Domitian he refers to as "the infamous one."

Corellius Rufus was a man of whom Pliny speaks in the most enthusiastic terms. "I remember," he says (*Epist.* i. 12), "in the reign of Domitian, to have made him a visit at his

anecdotes concerning, and sayings of, distinguished warriors up to his time, classified and arranged according to the occasions when their precepts were to have been put to use.[1] Says he in his Preface, iii.: "And, that they may be found in an order best calculated to distinguish such a variety of matters, I have divided them into three books, each of which forms a genus:—

"In the *first* are examples that relate to the affairs of an army previous to battle.

"In the *second* those which regard the battle and its consequences.

"The *third* contains stratagems used in the attack and defence of places.

"To each *genus* I have attributed certain *species*."

In fact each book descants upon a dozen or more *species*, and each *species* is sometimes illustrated by as many as fifty examples. He goes on to say: "And, as it is less the desire of glory than that of being useful that has dictated both this and my other works, I shall consider myself rather assisted than undervalued by any additions that may be made to it."

To this period of the life of Frontinus belong also Frontinus' services as augur and the episode related by Pliny, in his Epistles, v. 1, where the same Corellius, who has been already mentioned, and Frontinus are selected by Pliny to act as arbitrators, with himself, in a complex and delicate matter. Of this first-named office, of Frontinus' connection with it, and of his own accession to the office, Pliny speaks in his Epistles iv. 8, as follows:—

"My advancement to the dignity of augur is an honor that justly indeed merits your congratulations; not only as it is highly glorious to receive, even in the slightest instances, a testimony of the approbation of so wise and judicious a prince [Trajan]; but as it is also an ancient and sacred institution, which has this high and peculiar privilege annexed to it, that it is for life. Other sacerdotal offices,

villa near Rome, where I found him suffering the most incredible and cruellest tortures. Casting his eyes around the room, 'Do you know,' says he, 'why I endure life under these cruel agonies? It is with hope that I may outlive at least for one day that villain.' And, had he been given strength according to his resolution he would infallibly have had that pleasure!" He did outlive Domitian, but shortly after committed suicide by refusing all sustenance.

[1] A well-known military work, which has been translated into many languages: *Stratagems of War*, by Robert Scott, London, 1816; *Les Stratagêmes ou Ruses de Guerre*, Paris, 1772, etc.

though they may, perhaps, be equal to this in dignity, yet as they are given, so they may be taken away: but fortune has no further power over this than to bestow it. What recommends this dignity to me still more is, that I have the honor to succeed so illustrious a person as Julius Frontinus. He for many years, upon the nomination-day of persons proper to be received into the sacred college, constantly proposed me, as if he had in view my being his successor; and since it has actually proved so in the event, I am willing to look upon it as something more than accident."

This is the story of the arbitration above alluded to, as given by Pliny in v. 1, of his Epistles:

"A small legacy which has been left me has given me much greater pleasure than I should have received by a far more considerable bequest unattended with similar circumstances. Pomponia Gratilla, having disinherited her son Asudius Curianus, appointed me, and Sertorius Severus of praetorian rank, together with several Roman knights, her heirs. The son applied to me to give him my share of the inheritance, in order to make use of my name as an example to the rest of the joint-heirs; he offered at the same time to enter into a secret agreement with me to return my proportion. I told him, it was by no means agreeable to my character to seem to act one way, when, in truth, I was acting another; and that there was something of meanness in making presents to a man of his fortune, who had no children; besides it would not at all answer the purpose at which he was aiming. Indeed (I added) if I were to withdraw my claim, it might be of some service to him; and this I was ready and willing to do, if he could prove to me that he was unjustly disinherited. 'Let me prevail with you then,' said he, 'to be my arbitrator in this case.' After a short pause, I told him I consented to his proposal: 'For why,' said I, 'should I not have as good an opinion of my own impartial disinterestedness as you seem to have? But remember, I am not to be prevailed upon to decide the point in question against your mother, if it should appear she had just reason for what she has done.' 'Be it agreeable to your inclination,' he replied, 'which I am sure is always to act according to justice.' I called to my assistance Corellius and Frontinus, two of the most con-

siderable jurists which Rome at that time afforded. Attended with these friends, I heard the case in my chamber. Curianus said everything which he thought could favor his pretensions, to whom (as there was nobody but myself to defend the character of Gratilla) I made a short reply; after which I retired with my friends to deliberate upon the case, and then returning acquainted Curianus that it was our opinion, his conduct had justly drawn upon him his mother's displeasure. Some time afterwards, Curianus commenced a suit in the centumviral court against all the co-heirs except myself. The day appointed for the trial approaching, the rest of the co-heirs were desirous of compromising the affair; not out of any diffidence in their cause, but from a distrust of the times. They were apprehensive that what had been the case of many others might happen to them, and from a civil suit it might end in a criminal one, as there were some among them to whom the friendship of Gratilla and Rusticus[1] might prove extremely prejudicial: they therefore desired me to talk with Curianus. Accordingly I had a conference with him in the temple of *Concord:* 'Suppose,' said I, 'your mother had left you the fourth of her estate, or even suppose she had made you sole heir, but had exhausted so much of the estate in legacies that there would not be more than a fourth part remaining to you; could you justly have complained? You ought to be content therefore, if being absolutely disinherited, as you are, the heirs are willing to relinquish to you a fourth part: which, however, I will increase by contributing my proportion. You know you did not commence any suit against me; so that the prescription which I have gained by two years' peaceable possession, secures my share from any claim you can set up against it. But to induce you to agree to the proposals on the part of the other co-heirs, and that you may be no sufferer by the peculiar respect you show me, I offer to advance my proportion with them.'"

This offer appears to have been accepted, and Curianus signified his lasting and entire satisfaction with the way the whole affair had been conducted, by leaving to Pliny the legacy mentioned at the beginning of the above letter.

[1] Gratilla was the wife of Rusticus: Rusticus was put to death by Domitian, and Gratilla banished. It was a sufficient crime in the reign of that execrable prince to be even a friend of those who were obnoxious to him.

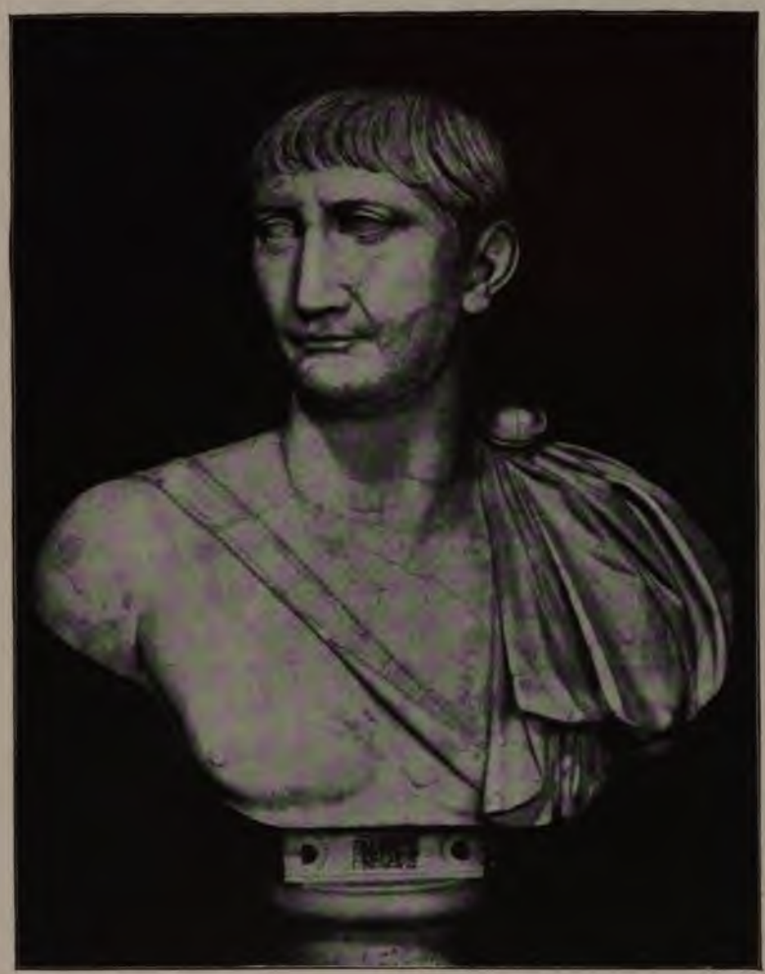
We come to the year 96, September 19, when Domitian fell by the hand of an assassin and was succeeded by Nerva, who was inaugurated at Rome December 18 following. Not long after, presumably,

EMPEROR *NERVA* AUGUSTUS CAESAR.[1]
A. D. 96–98.

— at all events in 97, — Frontinus was appointed, by Nerva, *curator aquarum*, which, following American titles, I translate: "commissioner of water works" of the City of Rome.

[1] Ancient work of art. In the Vatican Museum.

The fact alone that he was appointed by Nerva[1] is significant of Frontinus' character. At Nerva's choice as emperor, all that was worthy and patriotic in Rome took renewed courage. In the most



EMPEROR CAESAR NERVA *TRAJANUS* AUGUSTUS.[2]
A. D. 97–117.

accentuated way possible his was the coming into power of what we should now call a reform government, and to be immediately selected for so important an office as sole commissioner of the water supply of

[1] For a characterization of Nerva see any Roman history; or Pliny's letters ix. 13, &c.; or Martial xii. 6; Tacit. Agricola, 3: "He harmonized two things hitherto irreconcilable, — liberty and the Imperial power." [2] Ancient work of art. In the Vatican Museum.

Rome, by such a government, at once describes the man. As we shall see, he was the right man in this place, as he had been in others.

Of his services as water commissioner the present book will sufficiently speak. The book was begun by Frontinus immediately after his appointment, as is stated in Chapter 2. From Chapter 87 we see that it was written after the death of Nerva, who died January 25, 98. Chapter 93 confirms this, and speaks of Trajan, the successor of Nerva. Chapter 118 illustrates the difference between the reigns of Domitian and of Nerva in matters of the proper application of the public funds.

In the year 99, the Dacians, inhabiting portions of what is now Hungary, made inroads into the Roman territory, and Trajan took the field against them. It is known that Trajan thought highly of Frontinus as a writer on military subjects, and it is believed that Frontinus went to this war with Trajan. Certain it is, that A. D. 100, Trajan made Frontinus consul with himself. In 101 there was another war against the Dacians in which Frontinus may or may not have taken active part.

Near Oppenheim, in Germany,[1] has been found an inscription dedicated by Julia Frontina, presumably the daughter of Frontinus. It reads as follows:

DEO · APOLLINI · ET · SIRONAE
IULIA · FRONTINA · V·S·P·L·L·M·

Which may be translated:

Julia Frontina in fulfilment of her vow dedicates this monument to the god Apollo and to Sirona — joyfully, freely, dutifully.

It is supposed to date from about A. D. 84.

Near Cleves, not far from Xanten, the ancient Vetera Castra, in Germany near Holland, has been found this inscription:

I·O·M · IUNONI · MINERVAE · PRO · SAL ·
SEXTI · IUL · FRONTINI ·

Which may be translated:

To the best and greatest Jupiter, to Juno and to Minerva, in return for the recovery from illness of Sextus Julius Frontinus.

It dates either from the conquest of the Lingones or from a later German war.

[1] Dederich, Zeitschr. f. d. Alterthums-Wissenschaft, 1839.

There is also a lead pipe recorded as having been found in Ward VI. of ancient Rome, near the modern Via Tiburtina, inscribed:

SEXTIVLIFRONTINI

All of which signifies that Frontinus lived in Ward VI., not far from the artillery barracks of the present day on the Via Porta S. Lorenzo, and received his supply of water through this pipe.[1]

Borghesi, viii. 365, gives the ancestry of one Q. Sosius Falco, consul A. D. 193, and of Sosia Falconilla, his sister,[2] great-grandchildren of Julia Frontina.

"In whatever office he was employed," says the English translator of the Stratagems, "Frontinus, like Lord Bacon, seems to have considered himself a debtor to his profession. No object of his employment did he leave unexplored; nor was there any which he examined without useful illustration."

It was as a result of this that we have had handed down to us so large and so varied a collection of writings of this surveyor, soldier, jurist, gentleman farmer, and water commissioner of ancient Rome. This is the list:—

1. A Treatise on Surveying.[3]

Following my own ideas on the subject, I assume that a man who became in after life distinguished as a soldier, jurist, augur, and officer of state generally, must have written on surveying during the early years of his manhood. The work is known to us principally from the well-known Codex Arcerianus, kept at Wolfenbüttel. This is a sleepy little German town, which has, however, a famous library, containing 300,000 volumes and 7,000 manuscripts. There does not seem to be much of anything else of interest at Wolfenbüttel, and there are only 13,500 inhabitants; but they appear to prize that library, and have put it for safe-keeping into a new building so recently as 1887. Among

[1] Lanciani, *Frontino*, pp. 442 and 514.

[2] Renier, *Inscr. romaines de l'Algérie*, No. 1816.

[3] The Roman practice of the land surveyor is treated in *Die Römischen Grundsteuervermessungen*, Stöber, Munich, 1877. Or better in *Étude*, &c., *Agrimensores*, Paul de Tissot, Nancy, 1879; much of it, a translation of Frontinus' works on surveying, on boundaries, and similar subjects.

those 7000 manuscripts is the above named Codex Arcerianus,[1] one of the oldest Latin manuscripts in existence. It is supposed to have been written, possibly in the sixth century, certainly not later than the seventh. It appears to have been a book used by the Roman State employees, to aid them in the discharge of their duties, and contains, besides treatises on Roman law, much about land surveying, as taught by several Roman *agrimensores* (or *gromatici*) or land surveyors; among the lot, some pages by Sextus Julius Frontinus.

We thus find Frontinus one of that band of modest land surveyors, of whom it has been said in modern times that in their work of conservation of the mathematical arts, across the dark, and into the middle, ages, they were the humble co-laborers of the Arabian scholars of the time, and that to them is due the credit of having saved the geometry of the ancients for the benefit of the earliest years of the revival of learning, and thus for succeeding ages.[2] The writings of all these men bear distinct traces of the influence upon their authors of the teachings of Hero[3] of Alexandria, who flourished about 125 B. C.; and on the other hand, Book 2 of the Geometry of Anicius Manlius Severinus Boethius, born 480–482, and beheaded 524 (now known in the Saints' Calendar as St. Boetius), is held to have been founded on, and to be a partial reproduction of, the treatise on surveying of Frontinus.[4]

In the St. Peter's Convent of Salzburg, in the Austrian Alps, is a manuscript treatise on geometry, by Gerbert, who afterwards became Pope Sylvester II., and who wrote in the closing years of the tenth century. Some student of this Codex, writing in the twelfth century, has made a marginal note, which shows that he knew, and had read, the full treatise of Sextus Julius Frontinus on land surveying, described and given in part in the Wolfenbüttel Codex Arcerianus, just spoken of.[5]

Another old manuscript kept at Chartres, in France, whose author is unknown, is believed, by so careful a student as Chasles of the

[1] See *Die Römischen Agrimensoren*. Moritz Cantor, 1875, p. 95; *Vorlesungen ü. Geschichte d. Mathematik*, by the same author, p. 467. Description of the Codex Arcerianus in Lachmann, *Die Römischen (Agrimensoren) Feldmesser*, 1854.

[2] *Agrimensoren*, p. 185.

[3] J. Assoc. Eng'g. Soc., July, 1897, and *Notices et extraits des MSS. de la bibliothèque impériale* &c., 10—2, Paris, 1858.

[4] Cantor, *Gesch. d. Math.*

[5] *Agrimensoren*, p. 94, 202.

French Academy, to be a portion of this lost treatise on land surveying by Frontinus.[1]

All the Roman writers on surveying have as yet had but few readers, and still less, students, and have so far not been given the appreciation which is their due. When that shall have been done, it will appear that a system of land surveys and of land records, hardly inferior, in any respect, to the best that now exist, and reminding one of nothing so much as of the systems of land surveys adopted in the United States in the years immediately following the Revolutionary War,[2] existed in the Roman Empire 1800 years ago. Fields laid out in *centuriae*, or 100 lot plots, each field measuring about 2370 ft. × 170 ft. (this last = 10 Roman perches) may still be seen near Bologna, having still the precise boundaries given them by the Roman surveyors, and thus presenting the same appearance from the surrounding mountain tops that they did 1800 or 1900 years ago.[3]

THE GOD TERMINUS,[4] AFTER A STATUE IN THE LOUVRE.

In this practical, also semi-judicial, work of the Roman surveyor, Frontinus was apparently a pioneer, and a leader of men. His is the earliest Latin work on the subject, and remained the standard for a thousand years.

A good description of the standing in his community of the Roman land surveyor is given by Cassiodorus, and I quote the following from Hodgkin's translation of the "Variae," iii. 52.

[1] Cantor, *Gesch. d. Math.*, p. 500.

[2] See Journal Association Eng'g Societies, July, 1883.

[3] E. Réclus, *Nouvelle géographie universelle*, i. 344.

[4] All boundaries were parts of the special charge of the god Terminus, whose figure sometimes formed such a boundary monument. The placing of a boundary stone was accompanied by religious rites. (Siculus Flaccus (about 1st century) *De condicionibus agrorum*, 141 and 142.) Indeed, all the work of the surveyor was originally of a religious nature, and was executed by augurs, before there were any surveyors. The sacredness of land-marks was an ancient cult

"Written by Cassiodorus in the name of Theodoric. King Theodoric to the Illustrious Consularis. (On Roman Land Surveying.)

"We are sorry to hear that a dispute (which is on the point of being settled by arms instead of by the law) has arisen between the Spectabiles Leontius and Paschasius as to the boundary of their properties.[1] If they are so fierce against one another here in Italy, where there are mountains and rivers and the *arcaturae* (square turrets of the land surveyor) to mark the boundaries, what would they have done in Egypt, where the yearly returning waters of the Nile wash out all landmarks, and leave a deposit of mud over all?

"Geometry was discovered by the Chaldeans, who perceived that its principles lay at the root of astronomy, music, mechanics, architecture, medicine, logic, and every science which deals with generals. This science was eagerly welcomed by the Egyptians, who perceived the advantage it would be to them in recovering the boundaries of estates obliterated by the wished-for deluge[2] of the Nile.

"Therefore let your Greatness send an experienced land surveyor [*agrimensor*] to settle this dispute by assigning fixed boundaries to the two estates.

"Augustus made a complete survey of the whole *Orbis Romanus* in order that each tax-payer should know exactly his resources and obligations. The results of this survey were tabulated by the author Hyrummetricus. The professors of this science [of land surveying] are honored with a more earnest attention than falls to the lot of any other philosophers. Arithmetic, theoretical geometry, astronomy, and music, are discoursed upon to listless audiences, sometimes to empty benches. But the land surveyor is like a judge; the deserted fields become his forum, crowded with eager spectators. You would fancy him a madman when you see him walking along the most devious

(Deuteronomy, xxvii), continued, or produced from like causes, among the Romans. Orelli, 4332, is an inscription on such a bound-stone saying: "Whoever pulls up or destroys this, may he die the last of his race!" a terrible imprecation among the ancients. See also the sibyl's curse in "libris Vegoiae Arrunti Veltymno," another of the fragments by Roman agrimensors, where still more terrible punishments are invoked to fall upon him who shall displace a boundary stone.

[1] "Casarum." Casa is evidently no longer a cottage; perhaps the estate attached to a villa. There is probably still a flavor of rusticity about it.

[2] *Debita inundatione.*

paths. But in truth he is seeking for the traces of lost facts in rough woods and thickets. He walks not as other men walk. His path is the book from which he reads; he *shows* what he is saying; he proves what he hath learned; by his steps he divides the rights of hostile claimants; and like a mighty river he takes away the fields of one side to deposit them on the other.

"Wherefore, acting on our instructions, choose such a land surveyor, whose authority may be sufficient to settle this dispute that the litigants may henceforth cultivate their lands in peace."

2. Art of War.

And this is the testimony of Aelian[1] (about 100), an ancient military author, on the reputation of Frontinus as a writer on military affairs:

"But afterwards going to pay my respects to that illustrious character, your father, the Emperor Nerva, I spent some days with Frontinus, a man of consular dignity, and a person of the highest reputation for a consummate knowledge of the art of war; and finding, on conversing with him, that he had studied the Grecian theory with marked attention, I ceased to regard the purpose which I had formed of writing on the subject originally in contemplation as unimportant." . . .

"Concerning the tactics of Homer's age, we read what has been compiled by Stratocles, Hermias, and particularly by Frontinus, a person of consular dignity of our own age."

Frontinus' treatise on the Art of War is lost, except as it has been acknowledgedly incorporated in Vegetius (close of fourth century), on the Art of War. Vegetius[2] mentions Frontinus twice, as follows:

"The Lacedaemonian,—it is true,—the Athenian, and some other Greek authors, have left us several treatises on Tactics; but our business as Romans is to examine into the discipline of our forefathers only, the excellence of which extended their empire from a very confined territory over almost the whole world. These reasons induced me to undertake a faithful abridgment of the several military works of Cato the Censor, Cornelius Celsus, and Frontinus; of those of Paternus,

[1] See the *Tactics of Aelian*, by Henry Augustus, Viscount Dillon, London, 1814, Preface.

[2] Vegetius, *Art of War*, i. 8, and ii. 3.

that strenuous assertor of discipline and martial law; and of the ordinances of the Emperor Augustus, Trajan, and Hadrian. I advance nothing of my own authority, but confine myself entirely to extracts from the above mentioned authors."

"Cato the Elder, who was often consul, and always victorious at the head of armies, believed he would do his country more essential service by writing on military affairs, than by all his exploits in the field. For the consequences of brave actions are only temporary, while whatever is committed to writing for public good is of lasting utility. Several others have followed his example, particularly Frontinus, whose elaborate works on this subject were so well received by the Emperor Trajan. These are the authors whose maxims and institutions I have undertaken to abridge in the most faithful and concise manner."

3. STRATEGEMATICS.

This book has been already sufficiently described in this chapter.

4. ESSAYS ON FARMING.

Probably written before going to the wars either with Domitian or with Trajan. The preface says that Frontinus was interrupted in writing it by being obliged to go as a soldier.

I will not undertake to decide or elect in the discussion concerning which wars were meant. A quotation from this treatise is given by Gargilius Martialis, a writer on farming about A.D. 250.[1]

5. TREATISE ON BOUNDARIES, ROADS, etc.

Edited by Lachmann and others, Berlin, 1854.

6. A WORK ON ROMAN COLONIES.

Surveying, boundaries,[2] roads, colonies, — all these subjects savor strongly of the reign of Vespasian, who caused a new survey of all public lands to be made for purposes of taxation; who built many roads and rebuilt others; who gave particular attention to founding colonies

[1] Mai, *Auct. Class.*, p. 410.

[2] Boundary disputes were common. See Cagnat, *Epigraphie*, 1890, p. 271, C. I. L., i. 199, for such an one, B.C. 117; C. I. L., x. 7852, for one, A.D. 68; C. I. L., ii. 4125, for one, A.D. 193; p. 263, *Orelli*, 4031, for another. Also Tissot, *Étude*, etc., *Agrimensores*.

of veteran Roman soldiers. It is more than a coincidence that an able writer, who repeatedly insists that he wrote following his hard-earned experience, should have treated of these subjects in Vespasian's reign. It marks Frontinus as having been one of Vespasian's most valued and busiest public officers.

7. De Aquis (the book treated of in this volume).

The preservation of this book up to the time of the invention of printing, which forever secured it to posterity, reads like a romance. The world is plainly indebted for it solely to the labors of the pious monks of the Benedictine Monastery of Montecassino;[1] the parent monastery, founded by Saint Benedict himself in the year 529.

Situated about half way, on the railroad and the main highway, between Rome and Naples, and not far to the eastward of a line drawn from one to the other, on top of a mountain some fifteen hundred feet high, rising with a very steep pitch directly up from the valley carrying the highway, this monastery forms a marked object in the landscape. In 1866 this monastery became state property, but the original chapter of Benedictine monks still lives there, and they carry on their literary work as of yore, only that they now use the printing-press, the lithographer's stone, yea, even the camera and modern photographic reproduction processes, instead of the pen. They also keep a large school for boys, so that over three hundred people inhabit the mountain top. The old and the new are represented by such extremes in a place like this, that the contrast and contest between the two becomes very marked. When I was there in 1897, the corridors were lit by oil-lamps consisting of little tin pails of oil in which floated a cork that supported the wick. Nevertheless, we had telephone and

[1] For a description of Montecassino, see Mackey's *Life of Bishop Forbes*, 1888, p. 157; or Longfellow's translation of Dante's (1265–1321) *Paradiso*, 22, 37, and Notes. The celebrated Cassiodorus here joined the order of Benedictine monks, during the lifetime of Saint Benedict (about 537), and then founded a monastery at his birthplace, Scylaceum, the modern Squillace, over which he presided until his death, in 562.

Here lived the inventor of the modern method of notation for music, and many another worker and writer noted in his day. To engineers the monastery may also be a venerated spot from having harbored Castelli (1577–1644), the pupil of Galileo and teacher of Toricelli, all renowned hydraulicians, the latter of whom first stated the hydraulic law that velocities of efflux are as the square roots of the heads.

THE MONASTERY OF MONTECASSINO.

On the extreme left of the picture, near the top edge

telegraphic connection with the valley below, and there was in contemplation the lighting of the monastery by electric light, from a station to be established near the railroad. It will interest Americans to learn that the present chief abbot, the two hundred and seventh, and the lineal successor of Saint Benedict of the year 529, was, in the year of grace 1898, an American from Baltimore; except that to comply with Italian law, he had been obliged to renounce his American citizenship on being chosen chief abbot.

It is in such surroundings that we find this sole original manuscript of a work entitled — I give it in translation — "The Two Books on the Water Supply of the City of Rome," being a manuscript of the twelfth, thirteenth, or fourteenth century, as I have explained in the introductory chapter. Montecassino had been destroyed by Lombards, Saracenes, and Normans in 589, 884, and 1030, and by an earthquake in 1349, but this and other treasures survived the wrack and ruin of eight or nine centuries, to be discovered there, about A.D. 1400, by that indefatigable seeker and disseminator of recorded knowledge, Gian Francesco Poggio Bracciolini, ordinarily called Poggio.[1] We infer that, notwithstanding the great age of the Montecassino codex, it can present only approximately the precise form in which Frontinus wrote his commentary. Such manuscripts could not have lasted many centuries in troublous times; and a manuscript work composed in 97 and found in 1400 is already the result of probably half a dozen reproductions with the pen.[2] From about 1400 to the year 1459, when

[1] Shepherd's *Life of Poggio*, 1802, p. 110.

[2] See Longfellow's translation of Dante's *Paradiso*, note to 22, 74. Benvenuto gives us an interesting description of Boccaccio's (1313–1375) visit to the library of Montecassino, which he had from his own lips. "To the clearer understanding of this passage," he says, "I will repeat what my venerable preceptor, Boccaccio of Certaldo, pleasantly narrated to me. He said that when he was in Apulia, being attracted by the fame of the place, he went to the noble monastery of Montecassino, of which we are speaking. And being eager to see the library, which he had heard was very noble, he humbly — gentle creature that he was — besought a monk to do him the favor to open it. Pointing to a lofty staircase, he answered stiffly, 'Go up; it is open.' Joyfully ascending, he found the place of so great a treasure without door or fastening; and, having entered, he saw the grass growing upon the windows, and all the books and shelves covered with dust. And, wondering, he began to open and turn over now this book and now that, and found there many and various volumes of ancient and rare works. From some of them whole sheets had been torn out, and in others the margin of the leaves were clipped, and thus they were greatly defaced. At length, full of pity that the labors and studies of so many illustrious minds should have fallen into the hands of such

he died, Poggio found, copied, and distributed to various libraries many copies of ancient manuscripts, which I will not stop to describe. Of our MS. he made eight copies, which have formed, together with the original codex, the basis of many editions.

The best account I know of the manuscripts of Frontinus' "De Aquis" may be found in the preface to Bücheler's edition of 1858; but I do not consider that a reprint or extensive use made of this scholarly essay would properly form a part of a popular book such as this aims to be. Bücheler describes the eight manuscript copies made of the Montecassino original.

The list of the printed editions of an author was formerly of modest length and of considerable interest, but has necessarily become too long in the course of years and with the cheapening of the art of printing to maintain that interest.

The *editio princeps*, first printed edition, of Frontinus is that of Pomponio-Leto and Sulpicius, 1484–92. Then followed editions printed in Venice and Florence, 1495–97, five or six others in the sixteenth century, and three in the seventeenth century. In 1722 Poleni's elegant edition was published at Padua, and has remained a valued work. Other editions of the eighteenth century are those of Zweibrücken, 1788, and of Adler, printed at Altona in 1792. Bücheler's 1858 Leipzig edition is the standard text to-day for Latin scholars, but it may be profitably supplemented by Petschenig's article in "Wiener Studien," 1884, p. 249. A new edition of the "De Aquis" is in preparation as this is written, by Professor Gundermann, of Giessen.

Although I have adopted in this sketch of the life and services of Sextus Julius Frontinus the method of letting original documents tell

profligate men, grieving and weeping, he withdrew. And, coming into the cloister, he asked a monk whom he met why those most precious books were so vilely mutilated. He replied that some of the monks, wishing to gain a few ducats, cut out a handful of leaves and made psalters, which they sold to boys; and likewise of the margins they made breviaries, which they sold to women. Now, therefore, O scholar, rack thy brains in the making of books."

It is but fair to add that the date of Boccaccio's visit was just after the monastery had been pillaged by contesting soldiery, and when its resources and management were in gross disorder. This was about A.D 1350. Fifty years later Poggio found there the sole then existing manuscript of Frontinus' *De Aquis*. With Poggio and his time commenced what has, as may be appreciated from the above, not inaptly been called the "revival of learning," or the Renaissance.

their own story, it must be remembered that great uncertainties continue to attach to all ancient manuscripts, and will forever throw more or less doubt upon their testimony. The modern world has but feeble means of testing the reliability of their story of ancient times, handed down to us as it has been by centuries of copying with the pen, not to mention the wilful forgeries and changes made in them by the scribes. As a consequence, there is discussion without end as to the meaning of the ancient writers. Lifetimes are spent in the undertaking of elucidating their writings, only to have this work ignored or thrown aside by succeeding generations. Thus the student of the writings of his contemporaries, is not so much worse off than the student of original manuscripts in his search for the truth, as one might at first suppose.

The French translator of the Stratagems closes his sketch of the life and works of Frontinus as follows: "The whole of this chapter is nothing but a tissue of conjecture, which should not interfere with the liberty of the reader to think upon the subject-matter anything else that he may wish to substitute for what I have presented." And it is left to the kind judgment of the reader to determine whether the present author has done any better.

CHAPTER II

SPRINGS, WELLS, AND RAIN-WATER CISTERNS IN ANCIENT ROME

> Fontinalia a Fonte quod is dies ferial ejus; ab eo tum et in fontes coronas jaciunt et puteos coronant.
>
> VARRO (116–27 B. C.):
>
> *De lingua Latina*, vi. 22.
>
> Fontinalia, from (the god) Fons, because this is his festival; hence on that day they throw wreaths into springs, and garland wells.

FRONTINUS properly calls attention in the beginning of Book I. ("De Aquis," 4) to the sources of water supply in Rome antedating the construction of the first, the Appian aqueduct. "From the foundation of the city, for four hundred and forty-one years, the Romans were content with the use of waters which they drew, either from the Tiber, or from wells, or from springs." And he goes on to name three noted springs, and to call attention to the sacred character borne by springs[1] — the dwelling-places of Nymphae — among the Romans.

The presence of an ample water supply undoubtedly influenced the selection of the site of the city, as the place upon which to locate, just as it has and does and always will in multitudes of similar cases in peace and in war. In this respect certainly no better site could have been selected. It consists, in effect, of a bunch of detached hills and spurs formed by reason of the main river and of several smaller lateral streams having cut their channels deep down through the table-land over which they flow. No wonder that springs were plentiful, and to be found at the foot of these hills and in all these valleys. Add to this the fact that Rome, which is now some nineteen miles from the sea, was at the beginning of its history only about eight miles distant, and the abundance of ground water of all sorts underlying the valleys

[1] Dr. jur. Alfred Ossig, *Römisches Wasserrecht*, Leipzig, 1898, makes a strong argument in behalf of the meaning brook (as well as spring) for the Latin word *fons*; so that these may have been either springs, or spring-fed, (in contra-distinction to rain-water, or torrential), rivulets or brooks.

of Rome at the present day becomes a matter of course. "The first human settlement at the mouth of the Tiber, called Ficana, stood on the hill of Dragoncello, opposite Ponte Galera," says Lanciani.[1] When Ancus Martius, the fourth king, founded Ostia, as a substitute for Ficana, the mouth of the river had already advanced seaward about three and one third miles. And Ostia is now some four miles inland. Four miles in six hundred and thirty years is nearly thirty feet per annum, and this is also the present rate of progress. As the sea recedes, it is very evident that the water table in Rome must rise, other things remaining the same;[2] and no hydraulic engineer can read in Pliny ("Nat. Hist."36, 24) of Agrippa's having rowed into the Cloaca Maxima, the mouth of which it is now impossible to enter, or read the other facts given in Lanciani's book above quoted (pp. 15, 31) without finding therein proof positive of the ground water having risen in Rome during the historic period many feet, five or six feet, even though the bed of the river is claimed to have risen in eighteen hundred years less than three feet. Cicero says,[3] "He [Romulus] chose a place abounding in springs," and the remark characterizes the locality to-day more than ever, especially, of course, in the valleys.

Three of these springs are mentioned by Frontinus: "Camenarum, Apollinis et Juturnae," the first and last-named of which have been definitely located. The great storehouse of archaeological information and bibliography on the subjects treated of in Frontinus' "II. Books on the Water Supply of the City of Rome," is the commentary on this work written by Rodolfo Lanciani, and presented by him to the learned Accademia dei Lincei,[4] of Rome, in 1880; printed in Series 3, vol. iv. This is a quarto book of over four hundred pages. Though unfortunately buried up in the Italian language to the vast majority of readers, it will well repay any student of "De Aquis" to consult it.

The springs of the Camenae[5] — of the Prophetic Nymphs — were situated in the valley, also called the Egerian Valley,[6] just to the south

[1] Lanciani, *The Ruins and Excavations*, etc. p. 1.
[2] Lanciani, *The Ruins*, etc., p. 31.
[3] *De Rep.* ii. 6.
[4] Founded in 1608, and the oldest learned society now in existence.
[5] Vitruvius, viii, 3, 1, speaks of this spring as furnishing the best of water.
[6] Juvenal, *Sat.*, iii. 17; Livy, i. 21; Plut., *Numa*, 13.

of the Caelian, and running at right angles to the present Via Di Porta S. Sebastiano, and parallel to the city wall back of S. Giovanni in Laterano; a valley where in these degenerate days rules the contractor for filling in earth and rubbish by the cubic metre, and the builder of barracks and tenements, rather than the Prophetic Nymphs. In the early days of the Roman Republic this must have been a delightful grove outside the city gates, alongside of a brook naturally still in existence. It was reached by the Appian Way, and lay just outside the famed Porta Capena,[1] fair game for any Roman versifier of the day on account of the leaky condition of the aqueduct, a branch of the Marcia, which was carried over it.[2] Apparently it required resolution and a stout heart for a poet to pass out by this gate.

Somewhere in this same Egerian valley, it is supposed, was situated the spring called "Fons Apollinis."

"Fons Juturnae"[3] is the best located spring of the three that have been named. It was the source of, and but a short distance from, the lake of Curtius, so named after M. Curtius, the Roman youth who leaped into a sink-hole in the Roman Forum, the site of this lake, 362 B.C., in the belief that by so doing he was performing a patriotic duty. The spring of Juturna itself was the site of another still older Roman legend or story, which made it the place where the twins, Castor and Pollux, watered their horses after the battle of Lake Regillus (496 B.C.) in which they had helped the Roman arms, and had then brought to Rome the first news of the Roman victory. No wonder the place became well marked in Roman life and literature. Near it, in the Forum Romanum, stood the temple of Castor and Pollux,[4] of which the celebrated "three columns" remain to mark the

[1] See Kiepert and Hülsen, *Porta Capena.* Kiepert and Hülsen's *Formae Urbis Romae Antiquae* is much more than three maps. It also contains a table of about all the places in ancient Rome spoken of in literature, together with their locations on these maps, and references to their mention or descriptions in ancient and in modern authors, all done with that completeness which has become the characteristic of German literary work. In the light of such a result of the life-work of earnest scholars, it should be understood that a reference to Kiepert and Hülsen is the equivalent not only of the means of finding the location of the place referred to in Rome, but also descriptions of it in both ancient and modern literature.

[2] Martial, iii. 47; "At Porta Capena, which rains great drops." Juvenal, *Sat.* iii. 11: "Moist Capena."

[3] Kiepert and Hülsen, *Lacus Iuturnae.*

[4] "The temple in honor of the divine brothers was erected near the spring of Juturna." Ovid, *F.* i. 705.

site, just as they have stood for centuries. "The land between S. M. Liberatrice and S. M. della Grazie has been called *via trium columnarum* (street of the three columns) at least since the end of the fourteenth century."[1]

The ground in the vicinity of the remains of the temple of Castor and Pollux is full of springs at this day, and must always be, from the

THE DIOSCURI, OR CASTOR AND POLLUX.[2]

topography of the country about it. Indeed, when it is considered that the mouth of the Tiber, as has been stated, is constantly receding, and by the large amount of thirty feet annually, it will be evident that only by means of the large main drain, the Cloaca Maxima, passing through to the valley to the Tiber, and by reason of the ground-level rising in the course of ages, can the surface-level of this section

[1] Lanciani, *The Ruins*, etc., p. 273; Nichols, *The Roman Forum*, p. 74.

[2] As represented by the heroic size statues near the Quirinal Palace in Rome. Antique works of art.

of the city be kept above the level of the ground-water, and thus maintained as dry land. Otherwise, it would return to the condition in which the first inhabitants of Rome found it, before the Cloaca

"THE THREE COLUMNS."[1]

Maxima was built, — a marsh or lake between or back of the two hills, the Palatine and the Capitoline.

In the Galleria Lapidaria of the Vatican, No. 164, may be seen what is believed to have been a votive stone set up near this spring of

[1] Being remains of the Temple of Castor and Pollux. In the background, the buildings on the Capitoline Hill; on the right, the Arch of Severus. Between it and the three columns, the "Column of Phocas;" the "nameless column, with the buried base," of Lord Byron in *Childe Harold's Pilgrimage*.

Juturna.[1] After the exercise of as much diplomacy as would suffice to produce much greater results if applied in another cause, I have been enabled to present a cut of this rare and ancient monument to the readers of this book. The inscriptions on the two sides are nearly

VOTIVE STONE FROM *FONS JUTURNA*.[2]

identical. From the two combined, a meaning may be deduced somewhat as follows: —

"The two Tiberii Julii, Staphilus and Nymphius, father and son, at their own expense, to Juturna."

[1] Lanciani, *The Ruins*, etc., pp. 125, 134.

[2] No. 164, Galleria Lapidaria, Vatican. A very rare form of ancient monument.

A book could be written, as books have been written, on this worship of springs by the Romans. One subordinate branch of archaeology consists of the study of the articles of thank offering and of the tablets of maledictions (*devotiones*) which were deposited in springs and in tombs, respectively, as the favorite place to bring them to the attention of the higher powers, by the actors in these attempts to influence the course of events.

A good example of the first kind may be found in Lanciani's "Ancient Rome," etc., p. 46. This is too good a passage for me to forego the pleasure of quoting entire:—

"There was a well-known custom in ancient times of throwing votive offerings (*sacrae stipes*) into lakes, rivers, and springs which were sacred to the gods, or were famous for their mineral hygienic properties. The custom dates from very remote ages, as the following discovery will testify. In 1852, the Jesuit fathers, owners of the celebrated sulphur springs called by us 'Sorgenti di Vicarello,' by the ancients 'Aquae Apollinares,' on the west border of the Lake of Bracciano, sent from Rome a gang of masons to clear the mouth of the central spring, and to put the whole into neat order. In draining the well, a few feet only below the ordinary level of the waters, they came across a layer of brass and silver coins of the fourth century after Christ. Then they discovered a second layer of gold and silver imperial coins of the first period, together with a certain quantity of votive silver cups. In the third place they came across a stratum of silver family or consular coins belonging to the last centuries of the republic; and under this they found bronze coins,—sextans, quadrans, triens, and so forth. Seeing that there remained nothing but brass to plunder, after having partaken of the precious booty in equal shares, the masons resolved to announce their discoveries. It is unnecessary to say that when Padre Marchi, the well-known numismatist, ran to the spot, he found only a few hundred pieces of *aes grave signatum*, the earliest kind of Roman coinage. Under these there was a bed of *aes rude*,—that is to say, of shapeless fragments of copper, a kind of currency which preceded the use of *aes grave signatum*. At the bottom of the well, under the shapeless fragments of copper, there was nothing but gravel,—at least, the workmen and their leaders thought so. It was not gravel, however;

it was a stratum of arrow-heads and paalstabs and knives of polished stone, offered to the sacred spring by the half-savage people settled on the shores of the Lago di Bracciano before the foundation of Rome. This admirable chronological series of votive offerings, beginning with the age of stone, and perhaps with the first appearance of mankind in central Italy, and ending with the fourth century of the Christian era,

SCREENS AND OTHER RELICS.[1]

has been dispersed and made useless, in a certain degree, to science, partly by robbery, partly by ignorance. Still, a few hundred pieces saved by Padre Marchi, and deposited by him in the Kircherian Museum, Rome, are considered the finest numismatic group in existence with reference to the origin of Roman and Italian coinage."

Concerning the *devotiones*, I am led to refer to the little lead plate to be seen in the middle of the case of screens shown in the above figure,

[1] Screens cut from lead plate; terra-cotta drain-pipe; small marble fountain figure; in the centre of the framed case, an ancient *devotio*. From photograph taken in the Magazzine Archeologico, at Rome, by the author.

reproduced from a photograph taken by me in the Municipal Museum of the City of Rome (Magazzino Archeologico), situated not far from the Colosseum. This worn little lead plate is, as a matter of fact, out of place in its hydraulic surroundings, and was found, in 1876, on the Quirinal, in an urn containing also the remains of a human body.[1] Its history, and the history of the deciphering of the inscription upon it, which required some forty days of hard work with a magnifying-glass, may be found in "Bulletino della Commissione Archeologica Communale di Roma," April–June, 1897. The inscription is as follows: "I entreat you, most holy angels and saintly names, listen to the prayer of this magic writing: bind, shackle, embarrass, wound, seize, strike, annihilate, kill, dash to pieces the charioteer, Eucherius, and all his horses; to-morrow in the morning in the Circus of Rome; so that he will not leave the gates, nor contest with vigor, nor advance, nor press on, nor conquer, nor turn well, nor weather the *pallium*, nor push forward to win, nor come to front after having followed; to-morrow in the early morning and without help, now, now, quickly, quickly!"

A very similar inscription of this sort, found in Africa, is published in Boissier's "L'Afrique Romaine," p. 159.

The control and administration of the wells and springs in the City of Rome seem to have been under a different set of officials from that of the aqueducts.[2] One infers this from consulting the original documents given in Bruns' "Fontes," a law book treating of the origin of the Roman law, under the titles, *Negotia-Collegia-Collegium Aquae.*

There is an article on this subject in the "Zeitschrift f. geschichtliche Rechtswissenschaft," 1850, vol. xv., by Rudorff, p. 203, and by Mommsen, p. 345. They quote Saint Augustine, v. 462: "Lest any one during the festivity of St. John should dare to wash himself in springs, ponds, or rivers, by day or by night, since this wretched custom has remained till now from pagan custom," etc.

This was promulgated for the purpose of breaking up an ancient veneration of springs. Nevertheless, it has in a measure survived

[1] The reader is indebted to the very great kindness shown to the author by Professor Gatti, Secretary of the Archaeological Commission of Rome, for the pleasure of learning about this and about many another object treated of in this volume.

[2] See C. I. L., v. 154, 159, 161. "MAGISTRI · ET · MINISTRI · FONTIS" (keepers and tenders of springs).

down to the present day. By the "rules of the bath" of the seventeenth century, at Baden, near Vienna, a guest was subject to fine if he did not salute the water on entering and on leaving, or if he spoke of it as mere "water." And it is only a few years ago that a New York merchant was fined a most absurdly large amount and put to ridiculous annoyances for some trivial disrespect exhibited towards an official denominated the "Master of the Bath," in Bavaria, I believe.

TERRA-COTTA WELL CURBINGS AND DRAIN TILES.[1]

Besides springs, a multitude of which were named by the ancient writers in addition to those that Frontinus speaks of, and many of which have been located, and are in existence as of old though buried in many cases under many feet depth of filling, the Romans had wells and rain-water cisterns to draw from.[2] Such are illustrated and described, for example, in Middleton's "Remains of Ancient Rome," vol. i., pp. 113 and 162.

[1] In the foreground terra-cotta well curbings and drain-tiles. Vitruvius, viii. 1, 6, speaks of several lines of drain-tiles arranged so as to feed one well. The tiles shown answer to this description. In the background is a stone well curbing cut out of a single block of stone. From photograph taken in the Magazzino Archeologico, at Rome, by the author.

[2] Vitruvius, viii. 6, 14, describes rain-water cisterns.

Well curbings made of pottery may be seen in the Municipal Museum of the City of Rome, near the Colosseum, and are shown in Fig. 13.

So long as the aqueducts were liable to be cut off by skirmishing Latin tribes, wells undoubtedly had a great importance. We know that they were placed in the care of priests of various temples, just as in Germany in the middle ages they were in charge of the clergy, — at Heilbronn (Holy Well), Paderborn (Fathers' Well), etc. The Vestal Virgins, for some mysterious religious reasons, probably embodying an extreme of conservatism, were not allowed to drink water that had passed through such new-fangled inventions and unhallowed innovations as lead pipes. They drew their supply of water for domestic and sacrificial purposes from a large marble-lined tank set up in their House of the Vestals, and filled every day from some sacred source, such as the fountain of Egeria.[1]

Remains of other wells and cisterns of ancient Rome are described in the works of Middleton,[2] Lanciani, and others. They are a part of the primitive forms of hydraulic engineering.

[1] Middleton, *Remains*, etc., i. 315.

[2] Middleton, i. 116, and elsewhere.

CHAPTER III

FRONTINUS' DESCRIPTION OF THE NINE AQUEDUCTS;

FOR THE TOURIST, AND ARCHAEOLOGICAL

> Quod si quis diligentius aestimaverit aquarum abundantiam in publico, balineis, piscinis, domibus, euripis, hortis suburbanis, villis, spatioque advenientis exstructos arcus, montes perfossos, convalles aequatas, fatebitur nihil magis mirandum fuisse in toto orbe terrarum.
>
> PLINY (A. D. 23–79), *Nat. Hist.*, xxxvi. 24.
>
> But if any one will note the abundance of water skilfully brought into the city, for public uses, for baths, for public basins, for houses, runnels, suburban gardens, and villas; if he will note the high aqueducts required for maintaining the proper elevation; the mountains which had to be pierced for the same reason; and the valleys it was necessary to fill up; he will conclude that the whole terrestrial orb offers nothing more marvellous.

AS a rule, when the encyclopaedias, or the text-books, speak of the aqueducts of the City of Rome, the reader is given the statistics contained in Chapters 5–15 of Frontinus, and nothing more. These chapters state the source, course, length, and similar attributes of each of the nine aqueducts in existence A. D. 97, upon which our ancient author throws off care for an instant in the famous exclamation, of the 16th chapter: "Will anybody compare the idle Pyramids, or those other useless though much renowned works of the Greeks, with these aqueducts, with these many indispensable structures?" and then starts off upon a new line of statistics, giving the elevations, or the pressure levels of the waters of the several aqueducts and further information about them. In locating these nine aqueducts on the ground at the present day, and in describing certain of their features not noted by Frontinus, we may in this chapter profitably follow the order and method of Frontinus, above alluded to.

From an engineering standpoint, nothing can be plainer than a general design or plan of the principal aqueducts of ancient Rome. In a country like the Campagna, somewhat resembling the rolling prairies of Iowa or of Illinois, where the eye has an unobstructed sweep around the horizon, but with mountains bounding the rolling

PORTA MAGGIORE IN ROME.[1]

prairie on the one hand, while Rome is "seated on her seven hills" some twenty miles distant from the mountains at the other end of the line, a general oversight of the whole scheme of the works can be readily acquired. Of course there is plenty of water in the side-valleys of those mountains, and a marked ridge across the prairie prescribes the route which any self-respecting aqueduct builder of ancient or of

[1] The ancient *Porta Praenestina*, carrying Claudia and Anio Novus over the highway. The curious structure to the right is the tomb of Eurysaces, the baker, in which an attempt has been made to found a baker's order of architecture, by using, architecturally, various bread pans, dough-troughs, and baker's ovens. Middleton, ii. 275.

modern times would necessarily select to reach the higher elevations in Rome with his lines of masonry aqueducts. Whence it has happened that so many of the Roman aqueducts have followed nearly identical routes.

That there is a little brook running parallel to these structures, and on the very crest line of the ridge we are speaking of, need confuse no one. In a country of so ancient a civilization as this, it is not always easy to distinguish between the natural and the artificial, and it may well be that this brook occupies an artificial channel, and was thus conducted for purposes of irrigation. It serves irrigation uses to-day.

The key-point in Rome is the Porta Maggiore; in the mountains it is the country back of Tivoli. Any elevated view-point in Rome in the vicinity of the Central Railroad Station will give an idea of the panorama above described. On the right, facing the mountains, will be seen the peak of Monti Albani, also called Rocca di Papa (the Pope's Ridge), from a village of that name; while by letting the eye sweep around toward the left, Tivoli can be distinguished on one of the foot-hills of the Apennines. This is where the Anio River debouches upon the Campagna, and the valley of the Anio supplied the principal aqueducts of Rome in one shape or another with water, whether from the river itself, or from springs tapped in the valley of the river.

APPIA, 312 B. C. "De Aquis," 5, 7, 18, 22, 65.

> ideo aquam adduxi? ut ea tu inceste uterere? ideo viam munivi? ut eam tu alienis viris comitata celebrares?
>
> CICERO (106-43 B. C.), *pro M. Caelio.*

> Did I bring in the water, that thou shouldst use it sinfully? Did I build the road, that thou shouldst frequent it, accompanied by men not properly with thee?
>
> APPIUS CLAUDIUS CAECUS (3d century B. C.), represented as addressing Clodia (about 56 B. C.).

With Frontinus' account of the first described, the oldest of the aqueducts, — Aqua Appia, — the first of a long series of names distinguished in Roman history, mentioned by him, is brought to our attention. It constitutes a singular charm in the reading or in the

study of the classics, and of classical, especially of Latin, literature, that so much is known concerning the characters one thus encounters. Even their portraits, or portrait busts and statues, exist in unquestioned truthfulness of representation,[1] and new discoveries are constantly being made along all these lines.

At the very outset, we are thus brought in contact with two celebrated consuls, and in the builders of the first aqueduct, with one of the grandest characters of ancient Roman history, — with a man who was a century ahead of his time. Noted as an active and successful reformer in constitutional legislation, in finance, and in law, the builder of the celebrated Appian Way, and of the first aqueduct, — he was also active as an orator and a writer on grammar, and even as the founder of Latin literature, both of prose and poetry.

This man, then, made a new departure, — new at least, in Rome, though not an invention; for the construction of aqueducts had been practised in Greece, and in the still older civilizations of Asia, for centuries before the time of the Censor Appius. He and his fellow censor, the finder of springs (Venox), went out of the present Porta Maggiore on the Praenestine Way, then followed the Collatian Way, and about ten miles from Rome found the spring they were in need of, now to be seen at the bottom of some stone quarries not far from the Anio River; some 3,900 feet to the left, "between the seventh and eighth milestone" from Rome. The Roman mile was about 4,850 feet long, sub-divided into 1000 "paces."

From the spring they followed the roads in a general way towards Rome, which they reached "ad Spem Veterem." This was an open place, just inside the present Porta Maggiore, and crossing this, the aqueduct went on towards the present Via di Porta S. Sebastiano, crossed that valley near the ancient Porta Capena, a gateway in the wall of Servius Tullius, and ended on the shore of the Tiber, at the Via della Salara. The "Salinae," or salt warehouses, where Frontinus makes it end, existed there until A. D. 1888.[2] Both Parker and Lanciani have seen this aqueduct in modern times.

[1] See a most interesting chapter on this topic, entitled "Personal appearance of the Caesars," in Mrs. Frances Elliot's *Pictures of Old Rome*.

[2] Lanciani, *The Ruins*, etc., p. 530.

Frontinus says, that the portion within the city was reinforced by a branch from the Augusta, built by Augustus, who gave it the name of the "Twins;" or as we should now say, in the language of United States fire departments, Augustus "siamesed" the old and the new Appian aqueducts; the term "siamese" being derived from the well-known freak called the Siamese Twins, — a renewed proof of there

SOURCES OF APPIA.[1]

being nothing new under the sun, not even in familiar terms used in hydraulic constructions.

Frontinus says that "the distribution begins" at the Salinae. Of the meaning of this phrase more will be said later on, but it may be interesting to note in passing that the aqueducts all delivered into masonry cisterns or delivery tanks, whence the water was taken in separate lead pipes to each of the running fountains, private and public, and to the other places of water consumption.

[1] The incrustations caused by the excessively hard water of these springs are plainly to be seen.

As we have seen, all but about three hundred feet of this aqueduct was underground; this three hundred feet being on low arches parallel with the wall of Servius Tullius and across the valley now occupied by the Via di Porta S. Sebastiano. Except that it carried clean water, such a structure would not differ materially, or necessarily, from the walled and arched sewers, or drains for wet land, which, at the time, had existed in Rome for centuries, were it not for one other difference. Where Aqua Appia entered Rome, it was over fifty feet[1] below the surface of the ground, and this probably meant tunnelling instead of the comparatively shallow trenches which sufficed to put in drains for wet lands. I have not been able to find a description of the cross-section of this aqueduct satisfactory from the point of view of a builder. The cross-section given in "The Ruins," etc., by Lanciani, p. 48, I confess I do not understand. Various authors give the clear cross-section as about 2.5 feet wide by 5 feet high.

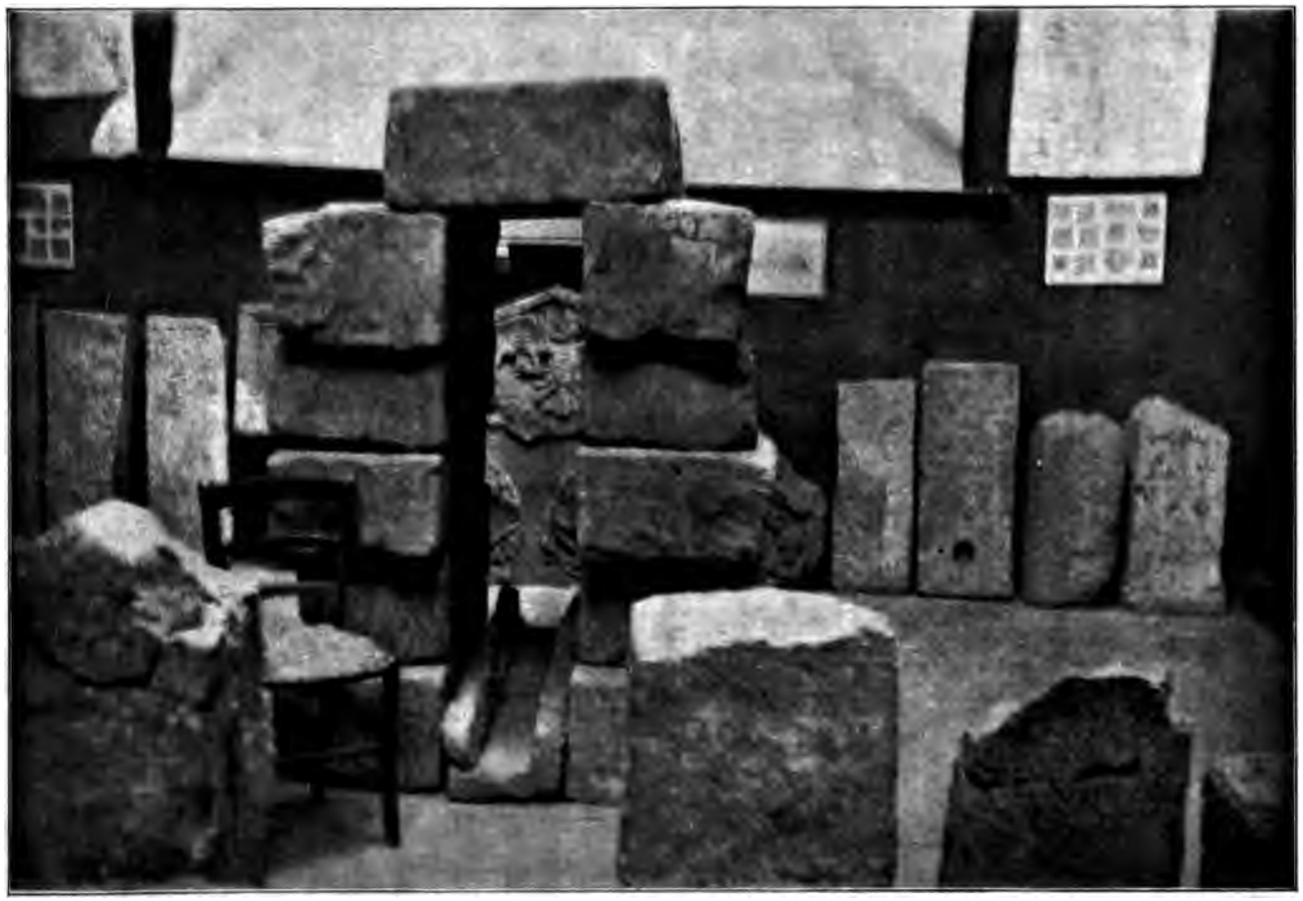
Sometimes the cover of the aqueducts is an arch, sometimes a slab or lintel, and again two slabs leaning against each other, like the roof of a house. And that these features do not indicate any chronological order is proven by their occurrence irrespective of the date of their use in the construction of ancient Roman sewers as well as of aqueducts. The former have been very perfectly described in the October, 1897, number of "Bulletin de la Société d'Encouragement pour l'Industrie Nationale," Paris, which gives also a description of the very perfect modern drainage works of Rome.

ANIO VETUS, 272–269 B. C. "De Aquis," 6, 7, 9, 18, 21, 92.

> Aquam Anienem de manubiis Hostium in Vrbem induxit.
> SEX. AURELIUS VICTOR (4th century),
> *De Viris Illustribus*, 33.
> He [Manius Curius Dentatus] brought into the city the waters of the Anio out of booty from the enemy.

This was another low-level aqueduct, though at an elevation some ninety feet higher than the Appia, and probably not considered a low-level aqueduct when it was built. It entered Rome near the present Porta Maggiore, at about the present ground level. Only about eleven hundred feet in length was on an artificial structure above the ground

[1] *De Aquis*, 65.



ANCIENT ROMAN SEWER.

A channel for the sewage carved out of stone; side walls and cover of dimension stone; made high enough to walk through. From photograph taken in the Magazzino Archeologico, at Rome, by the author.

level, out of forty-three miles in all, of which ten miles were up-stream from Tivoli.

The intake was out of the river Anio about half a mile up-stream from the monastery S. Cosimato. The railroad from Rome direct to the Adriatic, *via* Tivoli, runs through the valley of the Anio, and the nearest railroad station to S. Cosimato is Mandela. All about here is classic ground, it is perhaps needless to say. The station next before Mandela is Vicovara, where the pilgrim to, or perhaps seeker for, Horace's Villa on the Digentia,[1] the modern Licenza, leaves the railroad. Thence to Gallicano, the route of Anio Vetus is easily traced, and as may be noted, is a pioneer in marking out the general route of several other Roman aqueducts. From Gallicano towards Rome the route of Anio Vetus is not definitely known. We know, however, that a branch leading out of Anio Vetus was built by Augustus, beginning at a point some two miles outside of Rome and running towards the Amphitheatrum Castrense, a prominent landmark, and so on towards the Porta Latina.

The older or original aqueduct ran along about parallel to the line on which is now the railroad, after entering Rome near Porta Maggiore, and during the construction of the city works in that quarter of the city was uncovered, says Lanciani, more than twenty times. A long piece was built in the earth of the *agger* (fortification) of Servius Tullius, and ran parallel to the wall.

So that whereas the Appia was a case of two aqueducts "siamesed" into one delivery inside of Rome, the Anio Vetus was a case of a long aqueduct delivering river water to Rome through two branches. It may at once be noted, as Frontinus describes later on, that many of the aqueducts were arranged to deliver water each into several wards of the city, so that the supply could be maintained while certain aqueducts were out of use, — temporarily, for repairs; or needing reconstruction.

Very near the Central Railroad Station and about thirty feet outside the remains of the Servian wall and *agger*, fenced in and apparently religiously preserved by the city (1897), in the middle of a freight yard, there is a curious structure like a massive masonry round tower, some six feet in diameter and six or seven feet high,

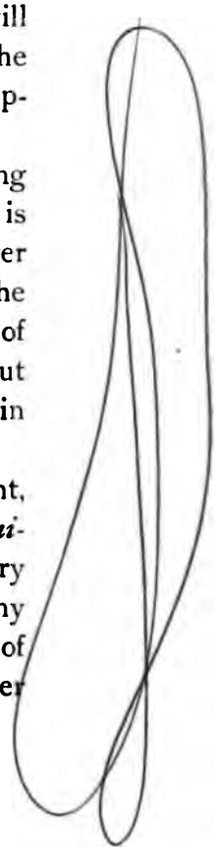
[1] G. Boissier, *Nouvelles Promenades Archéologiques*, 1895.

with a water-worn door opening on one side. It is shown in Lanciani's "Frontino," Plate 6. Usually it is called an inspection shaft, but it looks to me more like a structure designed to connect two aqueducts, so that the supply from the one could be transferred to the other (perhaps also from the lower to the higher aqueduct) pending repairs or similar interruptions to the use of either; and for use in keeping up the supply in several wards from only one aqueduct, as above noted.

The Comm. Lanciani called my attention, while in Rome, to rows of certain curious stone plugs in the bottoms of several aqueducts, which I deem to be another method for accomplishing this same object. Such plugs are shown in a MS. sketch by Poruzzi figlio, p. 648, kept in Florence (the plug is, I think, erroneously shown to bevel the wrong way) and were also found, Feb. 2, 1882, by Lanciani in Marcia, beyond Porta Furba, near Roma Vecchia. Placing a temporary dam in the aqueduct, and opening these plugs, would turn the water into the other aqueduct, and every water-works engineer will at once see the necessity of many such arrangements in line of the aqueducts to enable repairs to be made with a minimum of interruption to the water service.

While Appia was little more than a deep sewer, but conveying spring water, and possibly built by tunnelling, Anio Vetus is already a true aqueduct, bringing into the city the waters of a river tapped among the mountains, forty-three miles from Rome for the purpose of getting elevation, and skilfully led along the contours of the country so as to maintain elevation. Its cross-section was about 3.7 feet by 8 feet high, built of massive blocks of masonry, laid in cement and plastered on the inside.

To make aqueducts, reservoirs, and similar structures water-tight, the Romans used, on the inside, a form of concrete called *opus Signinum*[1] (so named from Signia, a city in Latium), in which pottery pounded up into fine fragments was mixed with the mortar. Any old aqueduct ruin will show specimens of it. All that is left of the channel of Anio Novus, on top of Claudia, consists for the greater part of the bottom lining, made of this *opus Signinum*.



[1] Vitruvius, viii. 6, 14, and ii. 5, 1; Pliny, *Nat. Hist.*, 35. Middleton, i. 79.

Piranesi gives a drawing showing the construction of this aqueduct, Plate X. Vol. I., which is reproduced by Lanciani, "Frontino," Plate IV.

Lanciani divides the route of the aqueduct into four divisions: first, from the intake to Tivoli; second, from Tivoli to Gallicano; third, from Gallicano to Porta Maggiore; fourth, from Maggiore within the city.

Division 1 has a mean fall of about 2 : 1000.

Division 2 has a mean fall of about 1 : 1000.

Division 3 has a mean fall of about 4 : 1000.

But we have no data as to the profile of the aqueduct within the limits of the several divisions.

MARCIA, 144–140 B. C. "De Aquis," 7, 9, 18, 19, 67, 76, 87, 91, 92.

> Marsas . . . nives et frigora ducens Marcia.[1]
> STATIUS (40–96) *Silvae*, i. 5, 26.
> Marcia, bringing the Marsian[2] snows and cold.

We now come to the construction of the first of the true high-level Roman aqueducts, carrying *spring* water into the city (as becomes an aqueduct of the Romans), and at the respectable elevation of 195 feet above sea-level; the favorite with poets and writers of all ages. This being the case, we find that Shakespeare, also, has his say about Marcia. In "Coriolanus," Act. II., Scene 3, Brutus says:

> "what stock he springs of,
> The noble house of Marcians; from whence came
> That Ancus Marcius, Numa's daughter's son,
> Who after great Hostilius here was king.
> Of the same house Publius and Quintus were,
> *That our best water brought by conduits hither;*
> And Censorinus, darling of the people,
> And nobly named so, being censor twice,
> Was his great ancestor."

Mr. J. H. Parker calls attention to several anachronisms wrapped up in this piece of verse, which I give, though not a follower, as a rule, of Mr. Parker, on matters of Roman archaeology.

[1] See also Pliny, *Nat. Hist.*, xxi. 24 and 41; and xxxvi. 15; Martial, vi. 42 and ix. 18, 8; Vitruvius, viii. 3, 1. Plutarch's life of M. Coriolanus.

[2] One of the ancient Latin tribes, living on the Apennines.

The Marcian aqueduct was built B. C. 146. As Coriolanus distinguished himself B. C. 491, people would hardly be talking about the Marcian aqueduct in his lifetime. Similarly, Censorinus, the only man who held the office of censor twice, lived B. C. 294, and would therefore not form the subject of conversation B. C. 491. Such is poetic license.

A DENARIUS OF Q. MARCIUS PHILIPPUS.[1]

The waters of Marcia are now used in Rome, having been brought in by an English company in 1870, — one of the last enterprises conceived in Papal times. The name of the works is now Acqua Pia, in honor of Pope Pius IX., or Marcia-pia. It was my very great pleasure to meet in Rome the chief engineer of this modern aqueduct, Col. Bernard Blumenstihl, and to receive from him one of the last copies

[1] From pride in their connection with the aqueduct Marcia, the *Gens Marcia* had this coin struck, representing their supposed ancestor, Ancus Marcius, and a crude representation of the aqueduct. The drawing is from Poleni's *Frontinus*. Other drawings have a flower, and still others the in-board end of an oar, or rudder, in place of the dog near the horse. It may, however, stand for the ancient sculptural support for a prancing horse.

unappropriated of his little book entitled "Brevi Notizie Sull' Acqua Pia (antica Marcia), etc.," 1872. This contains a full account of the author's search for and discovery of the ancient Marcian springs, and an account of their conveyance to Rome, besides much more that is most interesting to the hydraulic engineer. I may at once mention Colonel Blumenstihl's investigation of the quantity of water meant by the ancient measure called a *quinaria*, the first treatment of this sub-

ONE OF THE SERENA SPRINGS.[1]

ject, so far as I know, that is worthy of an engineer's attention, and unfortunately for the world's stock of knowledge and its means of distinguishing truth from error, hardly as yet heard of and still less appreciated by the general public. Of this, more when we take up the subject of the quantities of water carried by the several aqueducts or consumed in ancient Rome.

Concerning the real, genuine, original Marcian springs of ancient times, there has grown up a literature of its own, into the merits of

[1] The sources of the ancient, and again of the modern, Marcia.

which we cannot enter. This is not an archaeological treatise, and only such a one could do this subject justice. Suffice it to say, that Colonel Blumenstihl was satisfied that he had discovered the true Marcian springs, and the ancient masonry conduit leading from them. Further, that the water thus brought to Rome has well kept up the reputation of its ancient predecessor. I believe it has also brought much profit to its proprietors, which may not be without interest to the practical reader. To the student who would desire to investigate further the archaeological elements of the subject, Lanciani's "Frontino" will give full and ample data and arguments.

According to Colonel Blumenstihl, the ancient Marcian springs are now called the Second and the Third *Serena*, situated in the valley of the Anio (now called Aniene above Tivoli, and Teverone thence to the Tiber) and are on the north side of the Anio, a short distance down-stream from Agosta (nearest railroad station Roviano, about five miles down the valley). Another spring, now called *Rosolina*, still nearer to Agosta, is the one which could be conducted, according to Frontinus' "De Aquis," 12 and 14, into either Marcia or Claudia, and which he calls Aqua Augusta. This is the branch referred to in paragraph XX. of the so-called Ancyrean inscription[1] of the Emperor Augustus, as having been built by him 5 B. C.:

AQVAM · QVAE · MARCIA · APPELLATVR · DVPLICAVI · FONTE
NOVO · IN · RIVVM · EIVS · INMISSO ·

"I doubled the water supply called Marcia by turning a new spring into its channel."

The elevation of the second *Serena* is given by Colonel Blumenstihl as about nine hundred feet above the point of delivery in Rome, thirty-two miles away, an available fall of nearly thirty feet per mile. Every engineer will recognize the great value of so much fall to dispose of, and the facility this gives in the construction of any kind of an aqueduct or pipe line.

[1] So called from the place where found. Ancyra, the modern Angora, was a city in the province of Galatia. A full and illustrated account of this noblest of Roman inscriptions may be read in Duruy's *History of Rome*. See also Middleton, i. 384.

In another country having less elevation of the springs at an equal distance from the city, it would have required a much higher state of the art of levelling to have enabled the first of the aqueducts to be built. The line of Marcia yet shows the commonplace work of the rustic ditch-builder, and it is not until we reach Claudia, that the Roman leveller, *librator*, leaves the imprint of his work on the line in manner and form for his modern brother in the art to recognize and to approve.

Marcia, 146 B. C., Claudia, about A. D. 40, and the modern Aqua Pia, A. D. 1870, have practically the same termini. Marcia is nearly fifty-eight miles long, Claudia about forty-three miles, while Pia is only about thirty-three miles long.

The difference between the lengths of Marcia and Claudia is the difference between timidly running contours near the bottom of the main valley, together with running up and back on the side-valleys, as compared with planning to save distance by the skilful use of the level; while the line of Pia profits from all the advantages to be derived from the leveller's art, as well as from the facilities that are afforded by the use of cast-iron for making direct-line, inverted siphons.

From the Marcian springs, Marcia followed the northerly bank of the river as far as the monastery of S. Cosimato; thence, crossing over, followed the southerly shore to Tivoli; then turning to the left around Monte Ripoli it made towards Gallicano. In and about Gallicano the valleys are crossed by bridges and the spurs perforated by tunnels, conveying Marcia, Claudia, Anio Vetus, and Anio Novus, and making a perfect pattern collection of ancient aqueduct constructions. The nearest railroad station to Gallicano is Zagarolo, on the Naples line, and no engineer should miss spending a day in the highlands between Zagarolo and Tivoli, or Castel Madama. With a bicycle, or a hack hired by the week, according to the taste or purse of the engineer, starting from and returning to Rome, one might also pleasantly and advantageously make this trip.

The principal bridges crossing the Anio and the side-valleys of the Anio, may be given in tabular form:

Valley crossed or name of bridge.	*Aqueducts crossing.*	*Near what place.*
Anio.	Claudia. Marcia.	Monastery St. Cosimato. Vicovara.
Degli Arci.	Marcia. Anio Vetus.	Near Anio River, above Tivoli.
Degli Arci.	Claudia.	Tunnel, three miles long, under Monte Affliano.
Ponte S. Antonio.	Marcia. Anio Vetus.	Gericomio.
Ponti delle Forme Rotte, over Fosso di S. Gregorio.	Anio Novus. Claudia.	
Ponte S. Giovanni, Fosso delle Forme Rotte.	Anio Vetus.	
Ponte S. Pietro, Fosso delle Forme Rotte.	Marcia.	
Ponti dell' Inferno. Fosso dell' Inferno.	Anio Novus. Claudia.	
Ponte Lupo. Fosso dell' Aqua Rossa.	Anio Novus. Claudia. Marcia. Anio Vetus.	Gallicano.

A key-point is Ponte Lupo, crossed by Anio Vetus, Marcia, Claudia and Anio Novus, besides a carriage way and a bridle-path. This is a conglomerate structure composed of all the different forms of ancient Roman masonry, and embodying the changes in the mason's art of many centuries, — none the less interesting on these accounts.

I hesitate to enter upon the subject of Roman masonry. Choisy, "L'Art de bâtir chez les Romains," 1876, is a model work. Leger, "Les Travaux Publics aux Temps Romains," 1875, is a good book. Curt Merckel, Die Ingenieur Technik im Alterthum, Berlin, 1899, is another. These three books were written by civil engineers. "Die Baukunst der Etrusker und Römer," Darmstadt, 1885, by Prof. J. Durm of Carlsruhe, treats the subject from the standpoint of a distinguished and able architect. There are many more such works.

The Romans used dimension stone in vast quantities, especially in all the older structures. Then came the era of concrete and of brick.

SAND AND PEBBLE CATCH-TANKS NEAR TIVOLI.

Observe the dimension stone aqueducts of Marcia at either end of the tank built of small stone: *opus incertum*. The construction of this form of tank shown on p. 109.

Concrete was sometimes faced on the outside with small, say six inch square, stone, with pointed or rough interior ends, set with the diagonal lines of the stone faces vertical and horizontal, thus presenting on the outside a tessellated or net-work pattern. This was called *opus reticulatum*, and may be set down merely as an ancient Roman fad or fancy, that flourished for a while and had its day, as many another senseless kind of fashion has done before and since, in Rome and

ST. ANTHONY'S BRIDGE.[1]

elsewhere. It was handsome on the outside, "magnifique," but it was not good engineering. It was the proper form of construction for a floor or pavement, but not for a vertical wall.

In the treatment of concrete in general, on the other hand, the Romans were past masters. To cause distinct lines of pressure or of cleavage to form themselves within the body of concrete arches and domes, these were skilfully divided into voussoirs by lines of flat brick.[2]

[1] Now a bridle path; in ancient times carrying Anio Vetus, and over it, Marcia.

[2] See Journal of the Association of Engineering Societies, October, 1898, for an article on this form of construction. The main authority is the well-known work of Choisy, described in the list of such works on page xxi.

Fragments of a species of pottery were used to make one kind of concrete, and the same fragments ground to powder were presumably mixed with lime to make the tough Roman mortar, or the original "Roman cement," though we also know that certain volcanic earths were used for the same purpose.

There is a hill in Rome, Monte Testaccio, an artificial hill one hundred and fifteen feet high, composed exclusively of fragments of pottery.

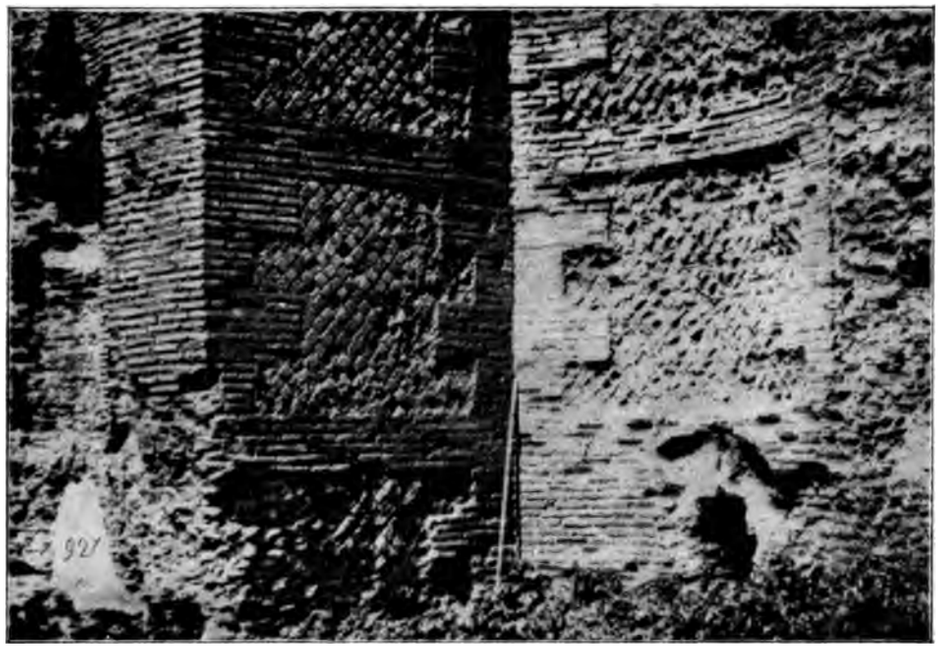
SPECIMEN OF *OPUS RETICULATUM*.[1]

So that the supply was evidently greater than the demand, in spite of their use in building constructions. This may seem strange indeed, until we reflect that the art of cooperage was probably practically unknown in ancient Rome, what are now hogsheads, boxes, barrels, and pails being made of pottery; the *amphorae* of ancient times. Even wheat was shipped in huge *dolia*, not in bulk. And as the diffident statement above made regarding cooperage is somewhat at variance with the encyclopaedias, I proceed to argue it.

[1] The scale is one of English feet.

1. Pliny, "Nat. Hist.," xiv. 27 says: "In the vicinity of the Alps, they put their wines in wooden vessels, hooped around."

This is usually quoted or referred to as supporting the theory that the Romans had coopered vessels. But if this were true, Pliny would not have thought it curious that such should be used "in the vicinity of the Alps."



SPECIMEN OF *OPUS RETICULATUM*, WITH BRICK QUOINS AND "LEVELLERS," AND CONCRETE BODY.

2. Daremberg and Saglio, 1887, "Dictionnaire des Antiquités," give a picture of a bas-relief, found in Augsburg, Germany, 1601, alleged to be a Roman wine cellar and men rolling barrels. I suggest that the men may be rolling stone columns, lagged and hooped for protection and for transportation purposes. It looks so to me. Vitruvius says columns were thus transported; and Roman wine cellars show rows of *amphorae*.

3. Marquardt, "Das Privatleben der Römer," 1882, a standard work, has a special chapter devoted to workers in wood, namely: carpenters, furniture-makers, and wagon-makers; but he says nothing of coopers.

4. To me it is not conceivable that coopered vessels should have been used in Pompeii, and no hoops or other remains of so much as a solitary pail have been found to date; especially when such things as loaves of bread, vegetables, even fine fishing-nets have survived.

5. Roman firemen, who were also policemen, used pails woven of esparto grass, and tarred to make them hold water; whence the ribald youth of the day were wont to dub them "sparteoli." [1]

MONTE TESTACCIO IN ROME.[2]

After this digression let us return from Monte Testaccio and the thoughts it gave rise to, to Marcia on the highlands near Tivoli.

Passing on towards Rome from Gallicano, Marcia runs underground to the seventh mile-stone of the Via Latina; thence to Porta Maggiore on arches, pieces of which remain in the vicinity of Porta Furba. On this last length, Marcia was later made to carry Tepula above it, and Julia on Tepula.

Marcia was eventually distributed to three sections of the city. Somewhere in the vicinity of Porta Furba a branch built by Cara-

[1] Lanciani, *Ancient Rome*, p. 224.

[2] On the left in the background. The Tiber in the foreground.

calla, A. D. 212, ran southerly, and entering the city between Porta Latina and Porta Appia, brought the Marcian water to the Antonine Baths, "*fonte novo Antoniniano*," C. I. L. vi, 1245. Arrived at Porta Maggiore the main supply was divided between an aqueduct running towards the baths of Diocletian, the Marcia Jovia of Diocletian, A. D. 284, and another, Rivus Herculaneus, or Neronian arches, that carried

DOLIA, OVER NINE FEET HIGH, IN THE COURT-YARD OF THE NAPLES MUSEUM.[1]

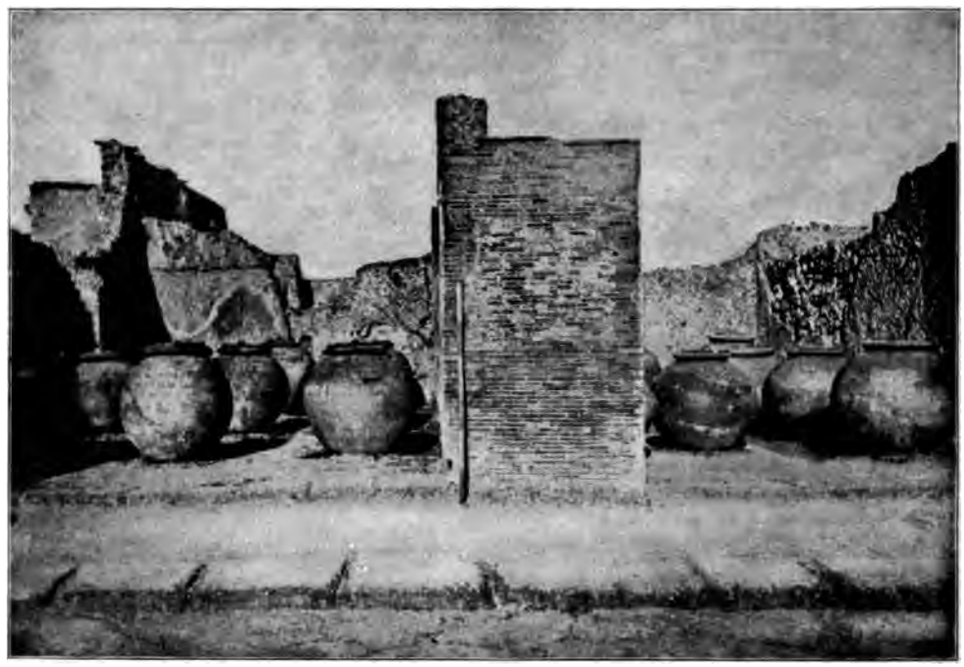
the water to the Caelian Hill and eventually over Porta Capena to the Aventine. As Frontinus says, it was the confessed policy of the water department of ancient Rome to cause each aqueduct to be in position to supply several wards of the city; also to have several aqueducts in position to supply each ward.

Appia, Anio Vetus, and Marcia are all built of rough-hewn, large dimension stone, 18″ × 18″ × 42″ or more, while the later aqueducts,

[1] Observe how small looks the long rain-coat laid on one of them. From photograph taken at Naples by the author.

with the exception of Claudia, show the skilful use of concrete and brick-work which distinguishes their era of Roman building operation.

The cross-section of Marcia near the head of the aqueduct is 5.7 × 8.3 ft. high; further on it reduces to 3 ft. × 5.7 ft. high. When reconstructed as the Acqua Pia in 1869, Colonel Blumenstihl, like the good engineer that he is, used three different sections of aqueduct, computed to discharge equal quantities on the three different slopes he



SHOPS IN POMPEII WITH *DOLIA* IN PLACE.[1]

gave his aqueduct. I question whether a Roman *mensor* or *librator* or *architecton* ever had the notion in his head of fitting size of cross-section to amount of slope, so as to produce a desired discharge. He might have tried a piece of his aqueduct, and finding the water flowing in it too slow for his taste, have then diminished the section, or increased the slope; but as we shall see, the idea or conception of cubic feet per second was very slow to penetrate the minds of men.

[1] The scale is one of English feet.

THE NERONIAN ARCHES ON THE CAELIAN HILL.[1]

TEPULA, 125 B. C. "De Aquis," 8, 9, 19, 68, 69.

In concedendo iure aquae ducendae, non tantum eorum in quorum loca aqua oritur, verum eorum etiam ad quos eius aquae usus pertinet, voluntas exquiritur, id est eorum quibus servitus aquae debebatur.

ULPIANUS (3d century), *Fr.*, viii. 39, 3.

In the matter of granting rights to divert water, not only the consent of those in whose lands the water rises is sought, but also of those to whom the use of the water belongs, that is, of those to whom is due the water easement.

On the slopes of Monti Albani, about half way between Frascati and Rocca di Papa, may be found the volcanic springs which supplied Tepula (a word derived from the same root as our word "tepid"), meaning slightly warm, to characterize the water found. These springs are

[1] The finest specimen of the peculiar Roman brickwork, built of large, flat brick, yet standing. These arches, also, are filled in with inferior brickwork to stop leaks.

now called Sorgenti dell' acqua Preziosa. Their temperature is about 63° F. This water flowed into Rome for ninety-two years, until Agrippa, B. C. 33, mixed it with Julia, so as to cause the amalgam to have a more agreeable temperature. The temperature of Julia being 50°, and their volumes as 1 : 3, the mixture would have a temperature of about 53° or 54°, which was well enough. Both waters had a separate channel from the spring down, then flowed in one and the same channel for four miles, and the mixture was then apportioned between two channels and thus entered Rome.

Tepula, built nineteen years after Marcia, marks a change from the exclusive use of dimension stone. Hence on, the Romans know the value of good mortar and of concrete. It is possible that they were led to this mode of construction in the case of Tepula by the greater convenience of thus building the new aqueduct on top of Marcia.

Tepula is a structure of homogeneous concrete, not divided up by layers of brick, as was done later, beginning about A. D. 100. The *opus reticulatum* also does not yet appear.

Tepula was 2.7 ft. × 3.3 ft. in cross-section, and entered Rome only some six feet higher than Marcia, on elevation about 201 feet above sea-level.

Having arrived at Rome on top of Marcia at the present Porta Maggiore, Tepula, and Julia as well, were both carried thus to the present Porta San Lorenzo, and easterly to a small reservoir or delivery tank, *castellum*, situated where is now the Ministry of Finance, Via Venti Settembre.

JULIA, 33 B. C. "De Aquis," 9, 18, 19, 69, 76, 83.

AQVA · IVLIA · IMP · CAESAR · DIVI · F · AVGVSTVS ·
EX · S · C · CLVI · PEDES · CCXL

(Inscription on boundary stone (*cippus*) of the lands appurtenant to Julia. Found 1886.)
LANCIANI, *Notiz. d. Scavi*, 1887, 558.

The Julian aqueduct. Augustus Caesar, Emperor [31 B. C. to A. D. 14], son of the sainted Julius Caesar. By vote of the Senate. Station 156, distance apart, 240 feet.

The source of Julia was further up towards Rocca di Papa, on the same line as the conduit of Tepula just spoken of, at a place now called

MARCIA, TEPULA OVER IT, AND JULIA OVER TEPULA ;

and four other aqueducts, near Porta Maggiore.

"Il fontanile degli Squarciarelli di Grotta ferrata" where cold springs of thrice the volume of Tepula gushed forth.

Julia rests directly on Tepula, and in some places looks as though it had been built at the same time with it, being built of the same form of concrete or small-stone masonry, without a marked dividing line between them.[1] For a large part of the way being on top, it has

PORTA TIBURTINA, SHOWING THE CHANNELS OF MARCIA, TEPULA, AND JULIA GOING OVER IT.[2]

disappeared, but at Porta Tiburtina the three aqueducts, Marcia, Tepula, and Julia, may yet be recognized piled up one on top of the other.[3]

The cross-section of Julia is 2.3 ft. × 4.6 ft. high, and the water entered Rome about on elevation 212 feet above the sea.

The arches of Marcia, Tepula, and Julia, where they enter Rome, were later, A. D. 272, incorporated into the wall of Aurelian,[4] and still

[1] See also page 164.

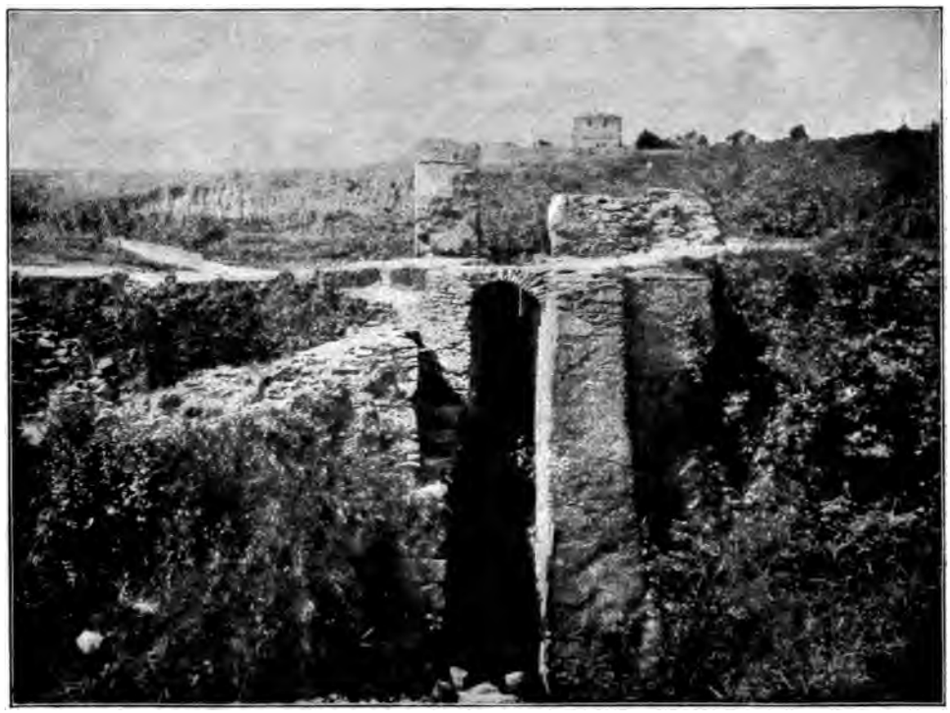
[2] From a photograph taken by the author. For the engineer, Porta Tiburtina is the most interesting aqueduct ruin in the City of Rome. It is a skew arch, with three aqueducts over it. The former springing of the arch, marked by a moulding, is now so near the ground level that this moulding is used as a bench. Note also the patch-work arching, to stop leaks from the channel of Marcia, filling up the original arches.

[3] See also page 165.

[4] LANCIANI. *The Ruins*, etc., p. 70, upon the manner and haste with which this wall was built.

later were crowded out, as it now looks, by their commonplace appearing successor, Acqua Felice, — as ugly as though built by the dead in spirit.

Julia branched off nearly at right angles from its companions, near Porta Tiburtina, towards the present Piazza Vittorio Emanuele, which still contains the imposing ruins of the ancient reservoir of Julia, built by Severus Alexander.[1]



ANCIENT DAM ON THE CRABRA.

In the paragraph relating to the brook Crabra, Frontinus throws a side-light on the history of irrigation in Italy, and also introduces the subject, so well known to the practical hydraulic engineer, of the "taking of water unlawfully." This term is used advisedly, for probably no man ever yet has been willing to admit that he had *stolen* water. So easy is it to let water flow hither and yon, when manipulating artificial water-courses: with such peaceful and quiet methods may this be accomplished, that there is more than the usual tempta-

[1] Middleton, ii. 325.

tion in the evil-doer in such cases, to see no evil in his actions. As it is now, so was it then, and we shall hear much more on this subject from the upright, energetic Frontinus.

This brook Crabra is readily recognized on the ground, and is the same brook which further down-stream runs parallel to the lines of the main aqueducts across the Campagna, and is now called the Maranna; which is, however, a name frequently occurring for small brooks in and about Rome.

At mention of Tusculum in connection with this brook, every one thinks of Cicero, and even so do we find several references in his writings to the subject of irrigation at Tusculum.

"In my Tusculan villa," says he, "I must pay a tax for the Crabran water, because I received my estate subject to this liability."[1] And in a letter written about 47 B. C.[2] he writes: "About the Crabra, in relation to which we are having a law-suit, although to be sure there is now an abundance of water, I would nevertheless like to hear."

There is also extant the description of an ancient marble plan found near S. Maria Aventina,[3] which indicates the hours allotted for irrigation to several properties, all figures carefully stated in words, not in the easily forged Roman numerals. Mommsen has learnedly written about this marble plan, and about another one found at Tivoli, in "Zeitschrift f. gesch. Rechtswissenschaft," xv. 307.

This last is the inscription given by Gruter, "Inscriptiones Antiquae Romae," 1690, p. 208, and reproduced in Lanciani, "Frontino," 537.[4]

When found it was already an "eaten-up stone," *lapide corroso;* it has since disappeared, and copies made of its inscription do not agree. Under the circumstances, scholars admit that none but extremely bold methods suffice to make sense of this inscription: that is to say, not only must the Latin be guessed at, but it must also be emended, to furnish a rational translation. The following translation I will be responsible for as representing irrigation practice of that date. As for the rest, it is the result of a protracted discussion with an excellent Latin scholar, undertaken for the purpose of meeting all the linguistic probabilities of the case, as well as its hydraulic requirements.

[1] *De lege Agr.*, ii. 2.
[2] *Epist.*, xvi. 18.
[3] Lanciani, *Frontino*, 325; C. I. L., vi. 1261.
[4] See also C. I. L., viii. 448.

"The water-right of Marcus Salvius Domitianus. The first three rights, each . . . digits long and 15 digits high. Above the apertures to the water-level (is for each the same height). The gateway of half the water is half the digits long. He shall receive the water from the first hour of the night to the tenth hour of . . . . The same man's remaining apertures are each . . . digits long and 15 digits high.

RECORD OF ANCIENT WATER-RIGHTS.[1]

"The water-right of L. Primus Sosius, (out of the Anio,) (or) of the tribe of Anio. Each aperture . . . digits long and three and a half digits high. He shall receive by these apertures from the . . . hour of . . . to the tenth hour . . ."

Apparently a "water-mark," set up to perpetuate the decision rendered in a quarrel about irrigation water-rights.

Another schedule for the horary distribution of irrigation water among many proprietors, who are named, has been found in Lamasba, in the domain of ancient Carthage, the Numidia of the Roman

[1] From Fabretti's *De Aquis*, p. 1757. *Aquae* evidently means water-rights, or as we would now say, "rights;" some run at will of the owner, others only between certain stated hours.

colonies. It is described with the hydraulic works, of which it forms a part, in Boissier, "L'Afrique Romaine," p. 140, and is given in C. I. L., viii. 4440.[1]

VIRGO. 19 B. C. "De Aquis," 10, 18, 22, 70.

> Respiciamus aquarum capita quantum Romanis moenibus praestent ornamentum. Currit aqua Virgo, sub delectatione purissima, quae ideo sic appellata creditur, quod nullis sordibus polluatur; nam cum aliae pluviarum nimietate terrena commixtione violentur, haec aerem perpetuo serenum unda mentitur.
>
> CASSIODORUS, Prime minister of Theodoric. (reigned A.D. 493–526).
>
> See how the aqueducts of Rome contribute to her ornamentation. Virgo's stream is so pure that the name, according to common opinion, is derived from the fact that those waters are never sullied; since, while all the others give evidence of the violence of rain-storms by the turbidity of their waters, Virgo alone ever maintains her purity.

The ancient Via Collatina (or Collatia) is supposed not to have been exactly on the line of the present road of that name. But not far from where the present road crosses a brook called Fosso del ponte di Nona, about eight miles from Rome, is a farmhouse called Salone, near a railroad station of that name, and near it are the remains of the ancient sources of Virgo. It will be noticed that these springs are only a short distance up-stream from those of Appia, and like them in the valley of the Anio. Virgo starts as though about to enter Rome at Porta Maggiore with the other aqueducts; the line can be traced by the air-shafts (*lumina*), but at a point about half a mile from this gate, turns to the north, and passing under Via Tiburtina, Via Nomentana, and Via Salaria, finally enters Rome under the Pincian hill, to the north of the Piazza di Spagna, with a reservoir near the present Via del Babuino at the end of the Vicolo del Bottino.

There is an excellent army topographical map of all Italy for sale.[2] It is published in handy, mounted and folded form, and while

[1] See also Cagnat, *Epigraphie*, p. 291.

[2] Bossi, *Corso*, 401 (1897).

making no pretence to assist the archaeologist, professional or amateur, is yet of decided service to him, especially if he have an eye for topography. The course of Virgo is very clearly given

"VIRGO;" FROM FABRETTI.[1]

on these maps. See the sheets called Roma, Castel Giubbileo, and Cervelletta.

Virgo formerly supplied the Baths of Agrippa, on the Campus Martius, also those of Alexander Severus. At present it supplies

[1] Frontinus' account gives a different reason for the name "Virgo." The figure is taken from Fabretti, and represents the young girl showing the soldiers where to find the spring.

the "ship-fountain" in the Piazza di Spagna, goes back of the houses on Via Nazzareno, where it may be seen, for instance, in the court-yard of No. 12 on that street, and ends at the well-known Fountain of Trevi. Many lead pipes of large size, sometimes encased in brick-work, leading from Virgo[1] have been dug up. This was the common way of continuing the conveyance of the waters, from the ends of the masonry conduits, as will be spoken of later.

VIRGO IN THE COURT-YARD OF NO. 12 VIA NAZZARENO.[2]

Virgo was a low-level aqueduct, the springs being only about eighty feet above sea-level, and entering Rome some thirteen feet lower. The intent was evidently by means of this aqueduct to flank the city, as it were, and thus reach the northwesterly low part of it and the Campus Martius directly with a masonry channel, or with short lines of lead pipe.

The cross-section of the channel of Virgo was about 1.6 ft. × 6.6 ft. high.

[1] Middleton, ii. 342.

[2] The inscription commemorates repairs made on Virgo in the time of Claudius. Middleton, ii. 343.

ALSIETINA. About A. D. 10. "De Aquis," 11, 18, 22, 71, 83.

> Navalis proeli spectaculum populo dedi trans Tiberim, in quo loco nunc nemus est Caesarum, Cavato solo in longitudinem mille et octingentos pedes, in latitudinem pedum mille et ducentum quo triginta rostratae naves, triremes et quadriremes, pluris autem minores, inter se conflixerunt. In iis classibus pugnaverunt praeter remiges millia hominum tria circiter.
>
> Paragraph XXIII. of the Ancyrean Inscription. (See above, under Marcia.)

> I gave the people the spectacle of a naval combat beyond the Tiber, where is now Caesar's grove; and for this purpose I caused the ground to be excavated for eighteen hundred feet in length, and twelve hundred in width. Thirty beaked triremes and quadriremes were engaged in this fight. Besides the rowers, three thousand men fought on these fleets.

All the aqueducts hitherto enumerated were for the supply of the principal part of the city, on the easterly bank of the Tiber. But there was also the "trans-Tiberine" section of the city to be supplied, and Alsietina was the pioneer aqueduct for this territory. Frontinus is in doubt as to Augustus' intentions in building it, but from the satisfaction Augustus took in having given this trans-Tiberine *naumachia* to the people of Rome, there is hardly a question that the motive for the construction of Alsietina was the supply of water to this marine circus. Lake Alsietina is now called Lago di Martignano, a small lake near and to the eastward of Lago di Bracciano. It is about six hundred eighty feet above the sea-level, is only some twenty miles from Rome,

NAUMACHIA.[1]

[1] From a coin of Domitian.

and the water reached Rome on elevation fifty-five, about: so that there is ample fall. The *naumachia* was in the flat land near S. Cosimato, and between it and S. Francesco a Ripa, and the foot of the Janiculan Hill, where some remains of it have been found.

EMPEROR CAESAR *AUGUSTUS*.[1]
Reigned 31 B.C.–A.D. 14.

Aqua Trajana, built after Frontinus' time, followed nearly the same route as Alsietina, but passing by Lago di Bracciano, tapped some springs to the north of that lake. Both of these aqueducts now form the modern acqua Paola, which supplying the *Trastevere*

[1] Ancient marble statue. In the Vatican Museum.

and its fountains, makes glad the elliptical waste in front of St. Peter's.

ANCIENT REPRESENTATION OF A "BIREMIS."[1]

CLAUDIA (38–52 A. D.). "De Aquis," 13, 14, 18, 19, 20, 69, 72, 76, 86, 87, 91.

> sed quanto pulchrius est, Claudiam Romanam per tot siccas montium summitates lavacris ac domibus liquores purissimos, fistularum uberibus emisisse?
>
> CASSIODORUS, Prime minister of Theodoric (reigned A. D. 493–526).

> But how much more beautiful [than the Nile] it is to see Claudia at Rome, carrying to the baths and domiciles, across the arid summits of the hills [Mt. Aventine] the waters that discharge from its productive channels.

The sources of Claudia were three springs, Fons Caeruleus, Curtius, and Albudino, in the valley of the Anio, and not far from the sources

[1] Sculpture showing galley having two banks of oars. In the Vatican Museum.

of Marcia. At the present day these bear the names S. Lucia, Casetta delle Forme, and Prima acqua Serena. At least this is the determination of Fabio Gori, a native of Subiaco in the Anio valley, a civil engineer, and one who made a life-study of the traces of all the Roman aqueducts. He was very active with Mr. J. H. Parker in his

CLAUDIA, OF DIMENSION STONE, AND ANIO NOVUS, OF BRICK AND CONCRETE, ON TOP OF IT.[1]

investigations, some twenty years ago, and with Belgrand about the same time.[2]

The cross-section of Claudia a short distance below the intake was about 3.3 ft. by 6.0 ft. high.

This is the aqueduct that seems to mark the highest development of Roman skill in hydraulic engineering, and is the pride of Roman

[1] The brick arch, placed under the seventh arch from the left, hangs by adhesion to the stone arch above it, is two abutment being gone.

[2] John Henry Parker, C. B., *The Aqueducts of Ancient Rome*, 1876. M. Belgrand, Inspecteur des Ponts et Chaussées, *Les Aqueducs Romains*, 1873.

authors. According to Pliny it cost 55.5 million *sestertii*, nearly three million dollars, but this included the cost of Anio Novus, built at the same time with it. For the two aqueducts this amounts to about $6 the running foot, which European engineers look upon as a high price to pay in those remote times, when slave labor was used. To an American engineer this does not seem a high price, and an American engineer "of the old school," if not of to-day, knows very well that slave labor is not economy. Brassey, the English contractor, has stated, that to move a cubic yard of earth costs precisely the same all over the world, — whether done by crude means and transported in baskets on the heads of men and women who are paid ten cents a day, or done with modern tools and by laborers who are paid $1.25 per day.

Claudia follows the general location of Marcia so closely that it will not be necessary again to describe the route.

It makes, however, a cut-off, by a tunnel about three miles long, under the former Mount Affliano, at the head of the Fosso degli Arci, not far from S. Gregorio, built some thirty-six years after the aqueduct was opened.

This is the tunnel described by Lanciani, "Ancient Rome," etc., p. 62. It was built in the reign of Domitian (before Frontinus wrote) by a contractor[1] named L. Paquedius Festus. We should nowadays call it a drift, being some three feet by seven feet high, and must have been very difficult to construct, at a time when even black powder for blasting purposes was as yet unknown. Common powder was known to the Chinese, A.D. 80, they having learned its manufacture supposedly from the East Indians. In 1085 the king of Tunis used it in a naval battle near Toledo. Blasting rock with it, is a German invention, by one Martin Weigel, in 1613, and the art was carried to England by German miners in 1670. But it was not until 1685 that earth tamping was invented. Before 1613 rock was either chiselled out bodily (the Roman tunnels show chisel marks about one inch wide)[2] or rock was taken out by building fires against it, and then

[1] Cicero, *Parad.*, 6, speaks of contracting for public works as one of the best ways for getting rich honestly.

[2] A Roman pick, used in tunnelling, and a miner's lamp were found in an uncompleted heading, about 1876. Lanciani, *Frontino*, p. 548.

throwing water on the hot rock. Pliny says: "Vinegar poured upon rocks in considerable quantities has the effect of splitting them, when the action of fire alone has been unable to produce any effect thereon,"[1] and before him, Vitruvius[2] says nearly the same thing, thus showing the antiquity of this method of tunnelling. Neither of them seems to admit it, but pouring on water "in considerable quantities," and under the like circumstances, would presumably have been as efficacious as the like quantity of vinegar. Plutarch credits Hannibal with the use of this method of excavating rock when crossing the Alps. After that it is mentioned in German mining literature as early as 1535. The method was in use in German mines near Gosslar and elsewhere in Europe, as late as 1867, and may yet be in exceptional cases.[3]

Paquedius Festus must have thought that he had taken quite a contract at Mount Affliano, for, from an inscription still preserved, it appears that he made a vow to restore a temple on top of the mountain he was tunnelling, in case he succeeded. He did succeed, July 3, A. D. 88, and the beautiful columns and fragments of statuary discovered on the summit of Mount Affliano have led archaeologists to infer that Festus did as he had said he would.

While we are on the subject of tunnels built by the ancient Romans, it may be well to give other examples.

Vitruvius speaks of both earth and of rock tunnels, and of "cut and cover" work, in his Book VIII.[4] Duruy's "History of Rome" speaks of a tunnel, 16,666 feet (over three miles) long, in line of the aqueduct in Antibes in France; and of another, to drain Lake Fucinus, in Italy, about A. D. 50, on which thirty thousand men worked eleven years and built a tunnel eighteen thousand feet long, through rock and clay, eighty-six to ninety-six square feet in section. There were thirty-two shafts, sixty-five to four hundred and twenty-five feet deep, and also inclined shafts or slopes, used in hauling out the excavated

[1] *Nat. Hist.*, xxiii. 27. [2] viii. 3, 19.

[3] This account of the history of blasting operations is taken from the book on tunnelling of Rziha, *Tunnelbaukunst*, 1867.

[4] A Greek tunnel, sixth century B. C., near Samos, is described in the *School of Mines Quarterly*, March, 1885, Columbia College. See also, Hero's writings, *Dioptera*. J. Assoc. Eng'g Soc., July, 1897.

material.[1] But the most vivid idea of Roman tunnel work can be got from Lanciani's "Ancient Rome," in some letters and reports that have been preserved. The correspondence commences thus, A.D. 152:[2]

'*Varius Clemens, governor of Mauritania,*[3] *to Valerius Etruscus, governor of Numidia:*[3]

'Varius Clemens greets Valerius Etruscus, and begs him in his own name, and in the name of the township of Saldae (Algeria), to dispatch at once the hydraulic engineer of the third legion, Nonius Datus, with orders that he finish the work, which he seems to have forgotten.'

Report of Nonius Datus to the magistrates of Saldae:

'After leaving my quarters I met with brigands on my way, who robbed me of even my clothes, and wounded me severely. I succeeded, after the encounter, in reaching Saldae, where I was met by the governor, who, after allowing me some rest, took me to the tunnel. There I found everybody sad and despondent; they had given up all hopes that the two opposite sections of the tunnel would meet, because each section had already been excavated beyond the middle of the mountain, and the junction had not yet been effected. As always happens in these cases, the fault was attributed to the engineer, as though he had not taken all precautions to insure the success of the work. What could I have done better?

'I began by surveying and taking the levels of the mountain; I marked most carefully the axis of the tunnel across the ridge; I drew plans and sections of the whole work, which plans I handed over to Petronius Celer, the governor of Mauritania; and to take extra precaution, I summoned the contractor and his workmen, and began the excavation in their presence, with the help of two gangs of experienced veterans; namely, a detachment of marine infantry and a detachment of Alpine troops. What more could I have done? Well, during the four years I was absent at Lambaese, expecting every day to hear the good tidings of the arrival of the water at Saldae, the contractor and his assistant had committed blunder upon blunder; in each section

[1] A full description of this work by Geffroy, *Revue Arch.*, July, 1878.

[2] Lanciani, *Ancient Rome*, p. 61, or his *Frontino*, p. 544, or, C. I. L., viii. 2728. The description of a monument found in 1866 at Lambaese in Africa.

[3] Neighboring colonies in Africa, in the Carthaginian country.

of the tunnel they had diverged from the straight line, each towards his right, and had I waited a little longer before coming, Saldae would have possessed two tunnels instead of one.'

Nonius Datus, having resurveyed the work, caused the two parallel tunnels to be united by a transverse tunnel; the waters of the river

END VIEW OF CLAUDIA, HALF BURIED UP, AND REMAINS OF ANIO NOVUS ON TOP OF IT.[1]

could finally pass the mountain, and their arrival at Saldae was celebrated with extraordinary rejoicings in the presence of the governor, Varius Clemens, and the engineer.

There were also deep open cuts; one near Chelvez, in Spain, being about one hundred and ten feet deep, in rock.[2]

When Claudia finally reaches the Campagna it carries Anio Novus above it thence to Rome. This forms the long line of aqueduct ruins

[1] Long line of arches on the left. From a photograph taken by the author.

[2] Lanciani, *Frontino*, p. 552.

near Roma Vecchia, which to the superficial tourist constitutes all there is of the "ruins of the aqueducts of Rome." Claudia is built of dimension stone, Anio Novus of brick masonry lined with concrete. The arches have eighteen to twenty feet span; thickness at crown, about three feet. The top of the arch stones forms the bottom of the channel of the aqueduct at the crown of the arch. The courses are about eighteen inches high and four of them make the aqueduct.

The piers are about eight feet thick in elevation. Any one of them will do for an abutment, and many of them have thus acted for centuries. There is no regularity either of span of arches, or of thickness of piers. But this defiance of modern laws of symmetry may be observed in some of the most celebrated structures of France and Italy, and was in vogue until the later years of the Renaissance.

Porta Maggiore is the ancient Roman structure built to distinguish the crossing of the ancient Via Praenestina and Via Labicana by these aqueducts. It was the invariable custom among the Romans to mark by an architecturally fine structure of this sort, the crossing of any important road by an aqueduct. The inscription upon it gives the history of the undertaking:

"Tiberius Claudius, the son of Drusus Caesar Augustus Germanicus, Supreme Pontiff, in the twelfth year of his tribunate, and fifth consulship, proclaimed *imperator* (on the field of battle) twenty-seven times, the father of his country, caused to be brought into the city at his own expense the Claudian water from the springs called Caeruleus and Curtius from forty-five miles away, also Anio Novus from sixty-two miles away."

It is a little cheapening to this high sounding proclamation, at least from an engineer's standpoint, to read just below it that Vespasian, only nineteen years later (including nine years of disuse), restored these aqueducts to usefulness; while a third inscription below this second one records that Vespasian's son Titus, in 81, ten years later, did the same thing. Of these and other repairs on the aqueducts I intend to say more in another chapter.

Where the ancient city wall runs parallel with or embodies these aqueducts, a tank or small reservoir may be distinguished, though incorporated in this wall. This must have been the place where the

waters of Claudia and Anio Novus were mixed.[1] Thence the waters of Claudia and of Anio Novus, or so much of them as was not led away in lead pipes, were conducted by the Neronian Arches, many of which

CLAUDIA AND ANIO NOVUS NEAR PORTA FURBA.[2]

are still standing, to the Caelian. These exhibit some of the best specimens of Roman brick work that we have; also, of that elegant joint-use of brick and concrete which Choisy has so carefully studied, and so well described. Domitian (A. D. 81–96) carried the water thence by a siphon (under 140 feet head), remains of which have been

[1] *De Aquis*, 20, 91.

[2] Repairs in brick-work, and in a composite of concrete and brick-work.

found, to the Palatine. This lead siphon was twelve inches in diameter. The parties who had charge of the work, the plumbers who laid the pipe, the house owners along the line and their plumbers, are all known, from inscriptions in raised letters on the lead pipes.[1]

Later, under Septimius Severus (193–211) this siphon was replaced, or possibly joined, by an aqueduct 140 feet high in the centre, and some 1400 feet long.

The level at which the water of the two aqueducts reached the Palatine was about 185 feet above sea-level, but at the Porta Maggiore Anio Novus was on elevation about 230, and Claudia only nine feet lower.

ANIO NOVUS, A.D. 38–52. "De Aquis," 13, 15, 18, 19, 20, 23, 69, 73, 86, 90, 91, 93.

> Vicit antecedentes aquarum ductus novissimum impendium operis incohati a Gaio Caesare, et peracti a Claudio. Quippe a lapide quadragesimo ad eam excelsitatem, ut in omnes Urbis montes levarentur, influxere Curtius atque Caeruleus fontes, et Anio novus. Erogatum in id opus sestertium L V D.
>
> PLINY (A.D. 23–79), *Hist.*, 36, 24.
>
> All previous aqueducts yield in rank to the one commenced by Caligula and finished by Claudius. The waters of the Curtian and Caerulean springs, and of Anio Novus were brought forty miles to Rome in manner such as to rise up on all the hills of the city. 55,500,000 sestertii were spent on this work.

Anio Novus has been described to such an extent while speaking of Claudia, that there remains but little to write about, except the sources of Anio Novus. They were a series of large reservoirs, constructed by damming the river, in the ordinary way of modern water-works engineers, and situated up-stream from Sublaqueum, the present Subiaco.

A mass of ruins of the dams forming these reservoirs, and of smaller intake reservoirs, still remains; which have been described, among others, by Parker in his "Roman Aqueducts." These reservoirs, built by Nero to adorn his country seat, were made the source of Anio Novus, under Trajan, with the hope of thus procuring water less

[1] Lanciani, *The Ruins*, etc., p. 186.

exposed to deterioration from freshets in the river. For the same purpose the clear water of what is now called Fosso di Fioggio, the Rivus Herculaneus of ancient times (not to be confounded, however, with other streams of the same name elsewhere, nor with the branch of Marcia of that name within the walls of Rome), was conducted into Anio Novus.

Before the times here spoken of, the intake of Anio Novus was further down-stream, within the present village of Subiaco.

The cross-section of Anio Novus was 3.3 feet by 9 feet high, and it must have been built so high, to allow it to flow deeper than the other aqueducts.

It has already been mentioned in speaking of Alsietina, that Trajana, a tenth aqueduct, built after Frontinus' time, followed nearly the same route as it. An eleventh aqueduct was Alexandrina, built by Severus Alexander, A. D. 226, also called Hadriana, of which some fine ruins remain out on the Via Praenestina, this side of the ancient bed of the former Lago Castiglione, and on the Via Labicana, beyond Casa di Cento Celle. Practically the same springs (on the Via Praenestina) are now brought to Rome by Acqua Felice, the ugly aqueduct.

Procopius, in his history of the Gothic wars, enumerates fourteen aqueducts, whence has come much shedding of ink, and learned discussions among old-time antiquarians. If a layman may state the result of his impressions received, it is that Procopius was mistaken. He several times counted as an aqueduct what was only a branch, and there were never more than eleven independent aqueducts, as have been above described.

Passing out by Porta Maggiore, let any one who wants to make a beginning of tracing the aqueducts ask for the road to Porta Furba, by way of Via de Mandrione. Let him note where the railroad cuts through the lines of aqueducts before reaching Porta Furba. The army map already described (sheet called "Roma") will show the way. Beyond Porta Furba lie the ruins of Claudia on the right, Alexandrina further off on the left; far beyond is Tivoli and the valley of the Anio.

To review the aqueducts it may be noted that arranging them according to their sources, we have Anio Vetus, Marcia, Claudia, and

Anio Novus with their sources above Tivoli in the valley of the Anio; Marcia and Claudia bearing spring water; the other two, river water.

Appia and Virgo begin near each other at springs in the Campagna valley of the Anio.

Tepula and Julia similarly have their origin at springs situated near each other, out towards that marked peak of the Alban Mountains on which is Rocca di Papa.

Alsietina was on the other side of the Tiber, with its source in a lake near Lago di Bracciono.

Trajana was a mate to Alsietina; and Alexandrina, to the present Felice, Alexandrina and Felice bringing in springs from out towards Gallicano.

Vergine, Felice, Paola, and Pia or Marcia-pia, the present sources of supply, are duplicates or reconstructions respectively of Virgo, Alexandrina, Alsietina and Trajana, and of Marcia.

Marcia carried above it Tepula, and above that Julia; and these three may be seen over Porta Tiburtina, Via S. Lorenzo, in Rome itself.

Claudia carried Anio Novus, and these two may be seen over Porta Maggiore, — "ad Spem Veterem," — at the gates of the present city.

The highest of Frontinus' nine aqueducts where they reached the city was Anio Novus, then Claudia, Julia, Tepula, Marcia, Anio Vetus, Virgo, Appia, and lastly Alsietina, a range from 235 feet, down to only fifty-five feet above sea-level. Trajana was two or three feet higher than Anio Novus, while Alexandrina was a little lower than Anio Vetus.

CHAPTER IV

AQUEDUCT BUILDING AND THE WATERS OF THE AQUEDUCTS

Barbaris qui Romulidas jungis auditorio.
DRACONTIUS (5th century), *Carmina minora* (ed. Duhn), i. 13.

By whom both the barbarians and Romulus' descendants are taught.

CHAPTERS 17–22, both inclusive, of "De Aquis," evidently form a division of the writer's work, such as he may have written at a single sitting, after having given us in Chapters 5-15 the brief history of each of the nine aqueducts in existence A. D. 97, as detailed in the previous chapter of the present book. Much of the matter touched on in "De Aquis," 17–22, has already been commented on, and all of it will be clear from the two maps prepared for this volume, the one showing the route of the aqueducts within the city, the other showing the lines of the aqueducts from their sources to the city. In studying these maps, we enjoy the same privileges which Frontinus says he enjoyed from the plans of the aqueducts which he had made for his own use. Lack of modern facilities of reproduction of maps no doubt prevented him from attaching copies of the same to his "II. Books" as he first wrote them. But had he and his immediate successors given us such copies, the monks of Montecassino would not have failed to reproduce them. Those people were great draughtsmen, and they made original drawings in the way of "illuminations" to some of their other manuscripts, that are marvels of delicate work.

But we can make such plans as described for ourselves, and as Frontinus says, 17: "In this way we reap the advantage of having, as it were, the works referred to directly before us, and of being able to study them, as though we stood by their side."

AQUEDUCT OF SEGOVIA IN SPAIN.

Built under Trajan, about A. D. 109.

Only eight feet wide, twenty-seven hundred feet long, ninety-five feet high. Still in use.

It must be remembered that we are speaking of the works of a very practical people. They were engineers by nature, rather than architects or men of science only; they taught the useful from choice, rather than that which was merely beautiful in design or tendency. They felt comparatively little predilection for "pursuing science for science's sake," as the phrase goes, while they pursued to the utmost of their abilities, and most ably for their day, that "art of directing the great sources of power in nature, for the use and convenience of man," which constitutes the profession of the civil engineer. The difference between their point of view and that of the Greeks was recognized long ago. Strabo, v. 3, 8, says: "The cities founded by the Greeks are reputed to have prospered by reason of the attention given by their builders to placing them in beautiful and favorable situations, in the vicinity of some harbor or in a fruitful region of country. But the Romans did mainly that which the Greeks neglected; I allude to paved streets, to aqueducts, and to those sewers, by means of which all the refuse of the city is swept into the Tiber."

Everybody knows how common a thing it is to find the remains of an aqueduct of Roman times in any country they once had possession of. Mommsen[1] names eleven Roman cities thus provided. Marchetti[2] describes nineteen such aqueducts besides those of Rome; Leger enumerates seventy-five; and there may actually be in existence the ruins of two hundred or more. Pliny the Younger was proconsul only a year or two, nevertheless he found time to cause not less than two aqueducts to be built during his tenure of office. He speaks of two, and may have built more.[3] The Roman aqueduct of the ancient Bologna is a remarkable work described by Gozzadini;[4] and there are many others described in the works of Rondelet, Leger, Merckel, and elsewhere.

Let us now get a clear idea why a people like this built these long and high aqueducts from choice. Let us stamp out, if we can, the shallow notion that those men did not know that water would rise

[1] *Z. f. gesch. Rechtsw.*, xv. 306.

[2] *Sulle Acque di Roma*, 1887.

[3] *Epist.*, x. 46 and 93.

[4] *Acqued. de Bologna;* also by Lanciani, *Frontino*, p. 549.

as high in a pipe as the source from whence it came. This belief can be disproved so easily that it becomes a marvel that so false an idea should continue to demand notice. Here, for example, is Vitruvius,[1] a Roman builder, the predecessor of Frontinus by about one hundred years, who wrote ten books on architecture, between 16 and 13 B. C. He tells us how to build what are now called inverted siphons.[2] He

PONT DU GARD, NEAR NISMES, SOUTHERN FRANCE.[3]

says it may be done with lead pipe, or with drain pipe. If of lead and ten feet long, make them weigh twelve pounds per inch in circumference; that is, make them uniformly a little over five-sixteenths of an inch thick. As he makes them one and one fourth inches to twenty-four inches in diameter, he leads people into making twenty-four inch pipe, that will stand only about forty-one feet head, while

[1] Vitruv., viii. 6, 5-6.
Lanciani, *Frontino*, p. 554, on siphons; or Rondelet, or Leger, or Merckel.

[3] Roman aqueduct built about A. D. 150; possibly A. D. 18 by Agrippa. The road-bridge is a mediaeval addition. One hundred and sixty feet high, top story ten feet wide, and nine hundred feet long.

the one and one-fourth inch pipe should stand nineteen times that head. These pipes, as we shall see, were all soldered, not seamless drawn, but the strength of the joint was equal to or was greater than that of the metal. However, they could be, and we know that they frequently were surrounded by masonry, whose weight could be depended on to increase the strength of the siphon. That this was done, both in the

ROMAN WATER PIPE MADE OF BORED-OUT BLOCKS OF STONE.[1]

case of the lead and of the drain-pipe siphons, we know from the remains of both kinds which have been found: as for example, the lead pipe siphons at Lyons, France, the ancient Lugdunum; being nine parallel lines of pipe, twelve inches to eighteen inches[2] in diameter, and one inch thickness of metal,[3] under two hundred feet head; and a drain-pipe siphon, reinforced with masonry, at Alatri, in Italy, built by L. Betilienus Varus, 125 B.C., and built to withstand some three hundred and forty feet head.[4] Vitruvius tells us how, in laying such pipe,

[1] Now in the Magazzino Archeologico at Rome. From a photograph taken by the author.

[2] 10-inch exterior diameter, says Gasparin. Thickness, not known.

[3] Leger, Alfred, *Les Travaux Publics aux Temps Romains*, 1875. Also Rondelet, 94. Excellent account of the Lyons Roman aqueduct, by Paul de Gasparin, *Ancien. Ingr. des Ponts et Chaussées*, to *l'Académie de Lyon*, Jany. 23, 1855.

[4] Lanciani, *Ancient Rome*, and his *Frontino*, 537. *Central-Blatt d Bauverw.* July 2, 9. 1881. This L. Betilienus Varus was a leader of men, and seems to have been a contractor, as may be gleaned from the inscription a grateful city set up to his memory. It may be trans-

the mortar at the joints should be made of lime and oil, what is now called "pointing up" mortar, and used to finish the joints on the outside of buildings; that at the angles should be placed a bored-out block of stone; that such siphons must be filled very slowly; and that it is a good plan to put ashes inside, to begin with, so as to stop fine leaks; a little trick of the trade called "puddling with ashes,"

PORTA TIBURTINA.[1]

which, in the case of canal gates and the like, is the common New England practice, about nineteen hundred years after Vitruvius.

Vitruvius learned much that he knew from the Greeks, and in speaking of inverted siphons, he states what the Greeks called them.

lated as follows: "L. Betilienus L. F. Varus caused these things to be made, which with the approval of the Senate are written below: Every lane in town; the gate leading to the citadel; the play-ground, sundial, market-place, seats, and plastering of the town hall, tank for bathing, tank at the gate, water in the town raised on arches to a height of 340 ft. He made his pipes strong. On account of these things the Senate twice ordered him to be made censor, and voted that a pension was due his son. The people gave this monument to the man who had twice been censor." C. I. L., i. 1, 166; Lanciani, *Frontino*, 556.

[1] Observe the moulding of the pediment cut away to gain room for still another inscription. The former abutments of the arch have been buried up in the course of time, and the moulding at the springing of the arch is now used as a bench.

Remains of Greek drain-pipe siphon aqueducts have been found in Asia Minor,[1] and are shown in modern books of travel.

In the "Natural History" of Pliny the Elder, written about A. D. 79, (31, 57), it is said in plain language, speaking of water: that "it climbs to the height of its own origin:" "subit altitudinem exortus sui." So also says "De Aquis," 18. "The several aqueducts reach the city

CITY GATE.[2]

at different elevations. Whence it comes, that some deliver water on higher grounds, while others cannot elevate themselves to the higher summits; for the hills have gradually grown higher, on account of the accumulation of rubbish produced by the frequent fires.[3] There are

[1] Belgrand, *Les aqueducs Romains*, 1875. Louvre, Greek inscription, No. 133, aqueduct at Mylasa, 323-317 B. C. Middleton, ii. 348.

[2] Porta Tiburtina or rather the gate built in line of Porta Tiburtina through the city wall, four hundred years later. From a photograph taken by the author.

[3] In Lanciani, *The Ruins*, etc., 102, are given some data permitting one to form a precise judgment as to the amount of débris which the life and death of the artificial elements that went to make up the City of Rome would produce in the course of time. Thus the threshold of Porta Tiburtina, built 4 B. C. by Augustus, is ten feet below the threshold of Porta S. Lorenzo, built in 402; making nearly one-fourth inch per annum. At the foot of the Palatine Hill, at the House of the Vestals, this layer of rubbish was seventy-two feet thick, the maximum

five aqueducts whose waters rise to all parts of the city, though some are forced up by a greater, others by a lesser head."

Hundreds of inverted siphons were used in the streets of Rome. From the ends of the masonry aqueducts, lead pipes carried the water to the points of consumption, and these pipes must have been inverted siphons in a multitude of cases.

It is also inconceivable that any people who had once thus used flexible lead pipe should have remained in ignorance of the nature of an inverted siphon.

Nor is it difficult, on the other hand, to find the reason why, knowing thoroughly how to build inverted siphons, the Romans made so seldom use of the principle, in the construction of their main conduits. They did simply what every engineer does at the present day, when working in different parts of the world. At each point of operation, a good engineer will use to the best advantage possible the material and facilities for his work, found at hand, for the time being; and this is what the Romans did. Not having cast-iron pipes they builded as could best be done without them; and were we deprived of cast iron, wrought iron, and steel pipes, we should, to-day, be obliged to build waterworks pretty much as they built them.

At irregular intervals there is a marked bend in these Roman aqueducts, the purpose of which has long troubled antiquarians. I suggest the same explanation that explains certain irregularities that some antiquarian may some time discover in modern engineering structures; such as the difficulties of securing the rights of way originally desired; changes made in the plans during construction; or later, during thorough repairs; and, finally, errors made in alignment. Lanciani, "Frontino," p. 554, suggests it was done to keep the aqueducts on one estate, and on its boundaries, instead of cutting the estate in two.

Air or inspection shafts (*lumina*) were frequent. They are especially well preserved on Aqua Virgo. Their frequent distance apart, 240 ft., was a well-known Roman surveyor's measure,

yet found; and partly caused by degradation of the hill, and of what stood on it. But a fair example is that of the foundations of the new Treasury Building, corner Via Cavour and Piazza dell' Esquilino, which had to extend fifty-three feet below the surface of the ground to reach the original soil.

derived from their duodecimal system of arithmetic, being two *actus* long.

The slope of the aqueducts was exceedingly irregular, as might be expected, although there were employees who did nothing but take levels,— the forerunners of the wielders of the rod and level of to-day. The methods and instruments they used, are described in works that have come down to us, but I will not stop to repeat the description. Given a knowledge of a plumb line, and the fact that a level line is perpendicular to it; also that water stands level in a groove and in a bent pipe; and given the use of sights to run in lines, and any intelligent mechanic could construct for himself, and use, an ancient Roman levelling instrument. Vitruvius had advised slopes of 1:200, but Frontinus makes fun of this,[1] calls it the way of the ancients, much as we should look down upon the ways of the colonial period in this country; and says that in his day, the art of levelling was better understood, and slopes of aqueducts were made flatter.

So little engineering work appears to have been done in treating of the Roman aqueducts, that I find it impossible to give good data respecting their slopes, despite the number and extent of their descriptions by antiquarians. Other ancient aqueducts, built by the Romans in their colonies, have been much better surveyed. Such have been found to have slopes ranging from 1:3000 to 1:600;[2] some having a very uniform slope, while others show plainly the difficulty experienced in sighting in small slopes with poor levelling instruments.

It would be interesting to have a hydraulic engineer turn archaeologist, and give us, before it is too late, the "hydraulic gradients" —not the slopes of the bottom of the channels—of as many of the ancient Roman aqueducts as he could find. These have been durably marked on the interior of all of them by the incrustations of lime-stone deposited out of the excessively hard water which they all carried. I cannot find that such work, worthy of the attention of the hydraulic engineer, has ever been done on the aqueducts of the ancient City of Rome but once, namely:—as detailed on p. 128 of Colonel

[1] *De Aquis*, 18

[2] Leger; and Belgrand. Rondelet's slopes, p 168, the basis of nearly all that is ordinarily quoted on this subject, are worthless; as any engineer will at once see on referring to the original statement.

Blumenstihl's little book on Marcia. He found a slope of 0.46 on eight hundred metres, or about 0.06 per one hundred for this incrustation in Marcia, near the intake, this line being discernible at heights of 3.3 feet, 2.0 feet, and 1 foot above the bottom, corresponding to high, mean, and low water mark. At this place Marcia is about five feet wide, whence he computes by a Darcy formula that when carrying water 3.3 feet deep, — the maximum depth, — the velocity was less than 3.3 feet per second (.987 m.) and the quantity was 1.48 cubic metres (about fifty-two cubic feet) per second; or about thirty-five million gallons per twenty-four hours.

A few weeks' work along these lines would determine the quantity originally carried by perhaps all of the ancient aqueducts, and I know of no other method by which this could be determined. It should be said, however, at once, that a knowledge, for instance, that Marcia carried thirty-five million gallons daily at the intake, would by no means give us the discharge of Marcia within the walls of ancient Rome. The leakage of all of these aqueducts must have been something enormous, not to speak of the unlawful drafts from them on the way. So that, as we shall see, it is very likely that less than half the water that was taken into the aqueducts ever reached the city.

The great characteristic of all the Roman waters is their extreme hardness, at least from the American point of view. They range from eleven (Paola) to forty-eight (Anio) French degrees of hardness, where our waters seldom attain five degrees. The question may be raised whether these waters have now the same characteristics that they had in ancient times; and as far as spring waters are concerned, they presumably have, in my opinion. One need but reflect upon the many mineral springs of Europe, at Baden near Vienna, Baden-Baden in the Black Forest, Wiesbaden, in fact, think of most any one of the mineral springs now known in Germany, France, and Italy, nearly all of which were first exploited by the Romans, to see how unchangeable within a period of thousands of years is this old mother earth which we inhabit. Presumably their volume of discharge also is now practically the same it has always been. That is the impression I have received, at all events, from examining the head masonry, built in Roman times, of some of these mineral springs. In the case of

Marcia, as we have seen, the ancient masonry channels were put into service in 1870, when these waters were again brought to Rome.

In the case of surface waters, the nature of the surface, whether wooded or with the forests removed, whether cultivated or uncultivated, must make a difference both in hardness and distribution of volume of discharge among the several months of the year. The tendency would be to have the water become harder and harder, and to have the fluctuations of discharge become greater and greater. Nevertheless, the greatest recorded flood in the Tiber occurred three hundred years ago,[1] and there are about as many recorded floods per five hundred years (about thirty) in one such space of time as in any other, from the beginning of the Roman historical period, 753 B. C., down to the present time, varying only as one might expect the number of preserved records of any kind of event to vary during the same time, — fewer of them being preserved in ancient times, nearly all of them nowadays. So that the conclusion would be that the surface of the drainage area of the Tiber has not changed very much, judged from a hydrological standpoint, for twenty-five hundred years, nor has the quality of the water and the discharge of the Tiber; and presumably not of the Anio or of the Crabra, or of any of the other country streams about Rome. Within the city this, of course, does not hold true; and a sewer may now represent what in very ancient times was a limpid brook flowing through the Valley of the Muses.

Some of these waters are almost lovingly spoken of in ancient literature. The poet Martial, a contemporary of Frontinus, makes frequent mention of the aqueducts. Epigram VI. 42, he says: —

"If the Lacedaemonian customs please you, you may, after a sufficiency of dry heat, plunge into the waters of Virgo, or of Marcia, which shine so brilliantly and are so pure that you would scarcely suspect the presence of water, and would imagine that you saw but the transparent *lygdinos* (a clear stone.)"

Strabo (v. 3–13) speaks of the Marcian water,[2] "which is drunk in Rome in preference to any other;" and Tacitus ("Ann.," xiv. 22) tells how Nero once polluted its sources. "Nero entered," he says, "for

[1] Lanciani, *The Ruins*, etc., p. 10.

[2] Lanciani, *Ancient Rome*, p. 59; Middleton, ii. 338; Martial, vi. 42, 18; and Vitruvius, viii. 3, 1.

the purpose of swimming, in the fountain-head of the Marcian water which is conveyed to the city. He was considered to have polluted the sacred water and to have profaned the sanctity of the place by washing his person there; and a dangerous fit of illness which followed left no doubt of the displeasure of the gods" — or of the chill Nero got by bathing in water of a temperature of about 50° Fahrenheit.

In bathing at a spring, Nero violated the public sentiment of the Romans, which, as we have seen, considered springs as something sacred.

"The most celebrated water throughout the whole world, and the one to which our city gives the palm for coolness and salubrity, is that of the Marcian Spring, accorded to Rome among the other bounties of the gods," says Pliny the elder ("Nat. Hist.," xxxi. 24). And in the next chapter he says: "On instituting a comparison between the waters of these streams (Virgo and Marcia), a difference, as above mentioned, may be immediately detected, the Virgo water being as much cooler to the touch as the Marcian is in taste," which opinion of a "savant" of that time need not disturb or puzzle us when we put it alongside of the many other specimens of the old sea-admiral's credulity or vivid imagination as laid down in his own special "wonder-working providence" of a book. Presumably what was colder to the touch of the palate was in his time colder, other things being equal, to the touch of the hand also, just as it would be now.

Both Vitruvius (viii. 5) and Pliny (xxxi. 22) speak of methods of testing the quality of water for domestic supplies. If it did well the work of cooking vegetables, — which means, was softer than another water, — had no sediment on the bottom of the vessel containing it after standing still, or on the sides and bottom by boiling down, nor had taste or odor, it was a good water. If the inhabitants who drank it looked healthy, it was good to drink, — a piece of wisdom which is represented by our proverb that "the proof of the pudding is the eating of it," but is nevertheless sadly neglected in these degenerate days. Instead, we put our trust in the say-so of the masters of the albuminoid ammonias and of the latest discovered forms of bacilli, be they benign or malignant bacilli.

Did the ancients ever purify or filter the water which they drank? It is believed that they did. In the museum at Naples are several vessels which we should now call water-coolers, one of which has its little bronze faucet, or plug-cock, still attached. They are made of lead, with raised ornamental patterns on the outside, and are lined with some form of cement. Loose discs inside these vessels have led

BRONZE BATH-TUB, WATER-COOLER, AND SIX-INCH PLUG-COCK IN THE NAPLES MUSEUM.[1]

to the belief that they contained filtering materials, and that the water was filtered as it passed through.

On a larger scale, we have the reservoirs at the head of Anio Novus, used for the purpose of drawing water that had been allowed to settle, as expressly stated in "De Aquis," 15; and the curious *piscinae*, of which there were many. It has been a puzzle to many writers how the Romans could have supposed that passing water through so small a reservoir as were these *piscinae* would at all purify it; and if it did

[1] From a photograph taken by the author. In 1880 on shaking the plug-cock I heard water splash around in it. In 1881 all of this water had been chemically absorbed, after having been imprisoned about eighteen hundred years.

not, why they should have persisted in building these things. Comm. Lanciani told me, while I was in Rome, that a friend of his, who owned an estate containing the ruins of one of these ancient *piscinae*, on digging into a little mound near it, discovered that this mound was composed of water-rounded pebbles, about the size of a large pea, all of which had apparently been dumped there from this *piscina;* and he

MODEL OF A ROMAN *PISCINA*, OR SAND-CATCH, KEPT IN THE MAGAZZINO ARCHEOLOGICO AT ROME.[1]

got enough of these pebbles from this mound to make a most elegant-looking covering to the walks in his garden. A jar of these pebbles is on exhibition (1897) in the Magazzino Archeologico of the City of Rome, near the Colosseum.

These data have led me to the conclusion, that the object of these *piscinae* was to catch these small stones as they came rolling along down the aqueducts, and thus to prevent them from getting into and stopping up the lead pipes, which were the continuation of the

[1] From a photograph taken by the author. From one of the top chambers the water flowed into the bottom chamber immediately beneath it, then horizontally into the next bottom-chamber, then up, and out on its way down-stream.

aqueducts, after they had entered the city. The construction of the *piscinae* was admirably designed to effect this separation of the pebbles from the water, as will be recognized from the photograph of a model of such a one herewith presented.

Hardness of the water was a great foe to the ancient Roman systems of water-supply, as it yet is, by the incrustations formed in the interior of the aqueducts, and of the lead pipes as well. Fabretti speaks of deposits made on the outside of the aqueducts at points of leakage, "as large as a hay-stack," which illustrates the amount of lime dissolved in the water that had to be contended against. To this day, the observant tourist may see lines of incrustation underneath the arches of Claudia, looking like the trunks of old wistarias, or some other creeper, clinging to the masonry, some of them nine inches in diameter, and presenting in section concentric rings, like the trunks of a tree. Similar incrustations may also be observed in the channels of all the old aqueducts. As the aqueducts themselves have for ages been used by the natives instead of stone quarries, there is sometimes nothing left of them, upon the ground, except these blocks of incrustation, erst formed upon the channel which is no longer in existence.

CHAPTER V

MEASURING WATER, A. D. 97

Mensor bonus vir et justus.
FRONTINUS, *Agrimensores*
(ed. Lachmann), p. 55.
The engineer, a good man and true.

IN Chapter 23 Frontinus takes up the distribution system, as we should now call it, of the water supply of the City of Rome, and as a preliminary and explanatory study he first considers the methods according to which water was then measured and allotted; a train of thought that carries him to Chapter 63, the end of Book I.

Let us see what ideas were extant on hydraulics, in Frontinus' time. The most troublesome point of ignorance he had to contend with was a total inability to measure the velocity of water, or even to rightly and fully grasp the idea of such velocity, whether as flowing in an open channel or in closed pipes. He accordingly compares streams of water merely by the areas of their cross-sections. A square foot of water is all one to him, whether it be one of the eight square feet of cross-sectional area of a stream in a conduit, or whether it be composed of the sum of two hundred or more cross-sectional areas of lead pipes leading out of delivery tanks to fountains, or to water basins, or to private consumers, and ending and discharging at as many different elevations. To the expert of to-day this seems excessively silly; and yet the same thing is constantly being done even now by those who ought to know better. The average man to-day will talk about "a stream of water that will fill a six inch pipe," a perfect parallel to the *quinaria* of Frontinus; and there are hundreds of deeds on record conveying "square feet of water" for power purposes, just as though the law of falling bodies and its application to hydraulics had never been discovered; and unmindful of the fact, as one old Italian writer on

water-rights has expressed it, that to speak of a stream of water by its area of cross-section is like estimating the volume of a cylinder merely from the area of its base.[1]

Chapter 35 gives us some of the ideas Frontinus had on velocity of flow, as follows: "Let us not forget in this connection that every stream of water whenever it comes from a higher point and flows into a delivery tank through a short length of pipe, not only comes up to its measure, but yields, moreover, a surplus; but whenever it comes from a low point, that is, under a less head, and is conducted a tolerably long distance, it will actually shrink in measure by the resistance of its own conduit; so that on these accounts, either an aid or a check is needed for the discharge." That is to say: an aid or a check is needed to make the pipe discharge the *normal* quantity allotted to *that size* of pipe.

He also says, speaking of Virgo, 70: "The gauging could not be made at the intake, because Virgo is made up of several tributaries, and enters its channel with too slow a current. Near the city, however, at the seventh mile-stone, on the field which now belongs to Cejonius Commodus, and where Virgo has a greater velocity, I made the gauging, and it amounted to 2,504 *quinariae*, being 1,752 *quinariae* more than was set down in the records. But proof of the correctness of our gauging is at hand; for Virgo discharges all the *quinariae* we found at the point of gauging; that is, 2,504." Meaning by this, that the sum of the areas of all the pipes leading out of Virgo was equal to the area of the cross-section of the stream at the second mile-stone, as found by him; and flattering himself that such equality of areas was the way to attain equality of volumes of discharge. He had already said, 65, in speaking of the Appia aqueduct: "At the Twins, which is below Spes Vetus, where it joins the branch of the Augusta, I found a depth of the water of five feet, and a width of 1 ft. plus ¾, making 8¾ square feet of area; twenty-two 100-pipes, plus one 40-pipe;" that is: twenty-two pipes each one hundred square digits in area (nominally at least), and one pipe of forty square digits (nominal area); "which makes 1,825 *quinariae*," says Frontinus. In point of fact, 5 ft. × 1.75 = 8.75 sq. ft., as he says. This equals 1,260 square inches (Roman). And as

[1] Romagnosi, German translation by Bunsen, p. 176.

one *quinaria* equals the area of a circle one and one-fourth digits in diameter, it is equal to 0.69026 square inches (Roman); and 1,260 square inches equals 1.825.4 *quinariae*, where Frontinus had 1,825. And then he goes on again, as before quoted, worrying himself into all sorts of explanations why his gaugings by areas, made irrespective of heads and velocities, do not balance. The frauds of the water-men, of the plumbers, and of others who draw water unlawfully, always furnish a handy explanation, however.

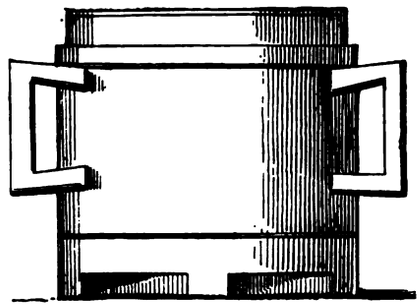
Another passage relating to the velocity of flow is 73: "Whence it appears, that the amount measured by me is none too large; the explanation of this is, that the more impetuous stream of water increases the supply, since it comes from a large and rapidly flowing river." That is to say: the unusual velocity causes that size of pipe to discharge more than it would ordinarily or normally discharge.

Hero of Alexandria, who, by means of his widely circulated writings, and possibly at the school in Alexandria, where Hero had formerly taught, may be considered as the teacher of Frontinus, had already said,[1] "Dioptera," 31: "Observe always that it does not suffice to determine the section of flow, to know the quantity of water furnished by the spring. This we said was twelve square digits. It is necessary to find the velocity of its current, because the more rapid the flow, the more water the spring will furnish, and the slower it is, the less it will produce. For this reason, after having dug a reservoir under the stream, examine by means of a sun-dial how much water flows into it in an hour, and from that deduce the quantity of water furnished in a day. Thus one has no need to measure the section of the stream. The measure alone of the time suffices to make evident the flow of the spring." This exhibits a clearer understanding of the beginnings of the art of measuring flowing water, and better practice than is anywhere shown in "De Aquis," or in Roman water-law, so far as I have seen it.

But some control of the amount drawn had to exist, and we accordingly find that the measure of a grant in the City of Rome, A. D. 97, was the right to insert, at a designated place in the public delivery tanks, which received their supply, either directly or through lead pipes,

[1] J. Assoc Engineering Societies, July, 1897.

from the public aqueducts, a circular, bronze ajutage, or short piece of pipe, stamped by the public authority, not less than about nine inches long and of a designated diameter; some fifteen such diameters being in ordinary use; and to allow water naturally to flow through this ajutage; it being the law, moreover, to ensure a natural flow through the stamped bronze ajutage, that the lead or other pipe immediately down-stream from it should have the same diameter as the ajutage, on a length of not less than fifty feet, measuring from the down-stream end of the ajutage.



MODIUS.[1]

This is a long definition of a grant; but, nevertheless, it did not ensure the draft of a definitely limited quantity of water, as Frontinus himself was well aware. He makes note, for example, that the direction of insertion of the ajutage, relatively to the direction of the current in the cistern, is of great moment. This is what he says on this point, 36: (An ajutage) "placed at right angles and level, it maintains its proper measure; set against the current of the water and sloping down, it will consume more; set sloping to one side, so that the water flows by, and inclined with the current, that is, placed less favorably for swallowing water, it will receive the water slowly, and in a scant quantity."

A mis-quotation, and a mis-translation of the mis-quotation, of a part of this sentence,[2] has been read to mean that a flaring ajutage will increase the discharge; thus attributing a knowledge of the properties of a Venturi tube to the ancients. The word and context prove the falsity of this translation, however.

Bearing on this same matter, and more nearly referring to the properties of a Venturi tube, is the following, 105: "It must also not be left optional to attach any kind of lead pipe to the ajutages; but there must rather be attached for a length of fifty feet one of the same

[1] From a terra-cotta lamp. The modius, the largest dry measure of the Romans, was a third of an amphora and a sixth of the Greek medimnus; it held nearly two gallons.

[2] "Calix devexus amplius rapit."

interior area as that which the ajutage has been certified to have, as has been ordained by a vote of the Senate, which follows:

"The consuls, Q. Aelius Tubero and Paulus Fabius Maximus, having made a report that some private parties take water directly from the public conduits, have inquired of the Senate what it would please to order upon the subject; upon which it has been ordered: It shall not be permitted to any private party to draw water from the public conduits; and all those to whom the right to draw water shall have been granted shall draw it from the delivery tanks, the water commissioners to direct at what points, within and without the city, private parties may erect suitable delivery tanks, for the purpose of drawing water from them, under grants which, in common with others, the water commissioners have located; and no one to whom a right to draw water from the public conduits has been granted shall have the right to use a larger pipe than a *quinaria* for a space of fifty feet from the delivery tank out of which he is to draw the water."[1]

Also, 112: "In some of the tanks, though their ajutages were stamped in conformity to their lawful admeasurements, it was found that pipes of a greater diameter were attached to them. As a consequence, the water, not being held together for the lawful distance, and being, on the contrary, forced through the short restricted distance, easily filled the adjoining larger pipe. Care should therefore be taken, as often as an ajutage is stamped, to stamp also the adjoining pipe over the length prescribed by the vote of the Senate which we have quoted. For thus only is the overseer relieved of every excuse he could make, when he knows that none but stamped pipes are allowed to be set in place." Now, the only way to have made a Venturi tube out of such a lawful arrangement of pipes would have been to expand the lead pipe fifty feet from the cistern *very gradually and uniformly* into a larger pipe.

Eytelwein made some experiments to test the point whether a Venturi tube would increase the discharge of a long pipe when placed at the outer end of it (Gilbert's "Annalen," Vol. VII., p. 295). He experimented with a one-inch pipe twenty feet long, and found that

[1] See also Venafrum aqueduct laws, *Zeitschr. f. gesch. Rechtsw.*, xv. 317; Venafrum, 44. Or see Brun's *Fontes*, sixth edition, p. 239.

when discharging freely *into the air* under a three-foot head it made no apparent difference in the discharge whether the Venturi tube was on or off. This, however, leaves the main question still undetermined; and it remains to be seen whether the same apparatus discharging *under water*, — that is, submerged, — or a Venturi mouth-piece discharging through a long pipe of the diameter of the larger end of the ajutage, will or will not discharge more than the small pipe alone. Venturi thought that it would; and I should not be surprised if it did, to put it no stronger.

Here is another correct conception of the matter of head acting on orifices entertained by Frontinus, though he spoke without knowledge of the laws of hydraulics as they have been developed in the eighteen hundred years following his time: 113. "In setting ajutages, care must be taken to set them on a level, and not place the one higher and the other lower down. The lower one will take in more, the higher one will suck in less, because the current of water is drawn in by the lower one."[1]

But the proper placing of the ajutages was evidently kept in the hands of the authorities; and Frontinus had clear ideas of the value of those lead pipes not less than fifty feet long, as we have seen, and that they should be stamped by the public authorities, as well as the bronze ajutage, as a safeguard against fraud.[2]

Lanciani (in his commentary on Frontinus, p. 575), and, presumably following him, Middleton (ii. 320) speak of two of these ancient Roman bronze ajutages (*calices*) as having been preserved, and being

[1] In *Zeitschr. f. gesch. Rechtsw.*, xv. 300, note 22, an emendation to an inscription found at Tivoli, namely, "Supra foramen in libram est," supplies so and so many inches. This would no doubt be good for modern times; but, considering the knowledge possessed by the Romans of practical hydraulics, its correctness must seem doubtful. We must note that it was not until 1764, in Modena, and for irrigation purposes, that we have any record, so far as I have been able to find, of anybody prescribing a definite head on an orifice as a *measure* of water granted. I get this from Romagnosi, *Irrigation Laws in Italy*, German translation by Bunsen.

Belidor, who wrote in 1737, says (*Archit. Hydr.*, ii. 306) that the "fontaniers" of Paris were not particular what head was acting on the orifice of the water-inch so long as it was a moderate one. Marchetti, p. 221, quotes Fea as saying that the water-inch was invented at Rome by Biscia in 1589-90. These data give some idea of the beginnings of the art. I suggest, therefore, a less rigid emendation, to the effect, possibly, that the space between the water-level and the several orifices set at that *castellum* must always be the same, which would correspond to *De Aquis*, i. 5.

[2] *De Aquis*, 103.

now kept, the one in the Kircher Museum, the other at the Vatican. I could not find the one said to be at the Vatican; neither in the library nor among the small bronzes; but the designated little tube of the Kircher Museum is positively not an ajutage for measuring water. Instead, it is probably the top of a drain-pipe from a sink or some

CALICES AND PIG OF LEAD IN THE NAPLES MUSEUM.[1]

such vessel, for it has two small pins crossing each other put through it, just as drain-pipes for kitchen sinks would have nowadays.

On the other hand, there are three little bronze pipes in the Museum of Naples, — in a glass case near the Farnese Bull (1897), Nos. 111,954, 111,955, and 111,956, — which the distinguished superintendent of this museum, M. Jules de Petra, was kind enough to let me measure and photograph, and also to write to me about. They are supposed to have been found at Pompeii. One of them is marked, with a prick-punch, "L ∴ MARI SOPATRI"; the other two are marked, in the same way, "A ∴ SEI ∴ GNOSTI". These I believe to be genuine ancient ajutages for defining the measure of a grant of

[1] From a photograph taken by the author.

water-rights, and the names given are supposed to be the names of the proprietors of the water-right granted. These ajutages are each nine inches long, and at the flange end have each an interior diameter of 0.72 inch.

The photograph also shows a pig of lead, found at Pompeii in 1882. The proprietor of the lead-works has his name on it,— P ∴ AEMILI ∴ GALLICI; and NER AVG., meaning NERVA AVGVSTVS, also lettered on it, shows it to be a pig of lead of the lifetime of Frontinus. Many such pigs of lead have been found; in the Tiber at Rome, where they had been dropped overboard near the wharf; in Great Britain near the smelting works, and elsewhere. In shape, size, manner of putting on letters and numbers, and presumably in quality of metal, they in no way differ from a pig of lead of modern times.

Returning now to a consideration of these Roman grants of water-rights, and framing a commentary on the form of grant above defined, for the purpose of leading to an effective understanding of its provisions, many points may receive notice.

(1) The ajutage must be entered at a designated point. Without this rule it is very evident that the utmost confusion would soon result. Each aqueduct carrying only a limited quantity of water, the right to draw from it, at any point, must be kept in the control of the public authorities, and not be left at the pleasure of owners of water-rights in general. The Roman water-rights did not "run with the land," but, on the contrary, expired with the decease of the grantee, or his alienation from the plot supplied; or, in case of a syndicate, they expired with the decease, or similar alienation, of the last member of the original syndicate; water-rights thus terminating reverted to the authorities, and were granted to other applicants. An exception to this rule was found only in the case of ancient grants for public baths, which were perpetual grants, running with the land (but presumably limited to the purpose named).

From all this, it will be recognized how important it was that the public authorities should determine at what points definite quantities of water should be drawn; that they should have the setting of all ajutages; and should be in position to keep an accurate record of such.

(2) The ajutage must be of a prescribed form, length, diameter, and material, and must bear the official stamp of the proper authorities.

Frontinus tells us "De Aquis," 24, how originally there were square inches and square digits, and round inches and round digits, of water-rights in use; until finally, custom settled down to the use of only fifteen circular ajutages, varying in size (38–63) from the *quinaria*, one and one-fourth digits (.907 inches English) in diameter, up to a pipe "12 + 4/12 + 1/48 digits" (= 8.964″ English) in diameter; how originally these were made, apparently, by handing out a plate of lead of definite width, to be bent or formed into an ajutage; (25) which method was subject to abuse, by having the lead beaten out thinner, so as to form a tube of greater diameter, until finally the ajutages were made of bronze, not less than "12 digits" long, and stamped by the deputy commissioner (*procurator*).

Says Frontinus, 36: "Bronze seems to have been selected on account of its hardness; difficult to bend and not easily extended or contracted."

In saying this, Frontinus selects only between bronze and lead. If iron pipes had been current in his day, he would have been obliged to add that bronze should be thus used, as it is not subject to rust in running water, and that iron could not be used in place of it on account of its rusting so badly.

Frontinus does not say, but the ajutages were presumably stamped on their interior surfaces, and in several places, and near the ends; or else they could have been bored or filed out larger, or have had the edges flared or rounded off. Chapters 112–115 give a neat passing picture of some of the frauds readily practised in ancient Rome, in the matter of an abuse of water-rights, or of thefts of water.

Says Frontinus, 112: "Having now explained those things that relate to the administration of water for the use of private parties, it will not be foreign to the subject to say something and to give examples of how we have detected some in the act of contravening the most wholesome ordinances. In a great number of delivery tanks I found ajutages of a larger size than had been granted, and among them some that had not even been stamped. But whenever a

stamped ajutage is larger than its legitimate measure it reveals an endeavor to curry favor on the part of the deputy commissioner, (*procurator*), who stamped it; but when it is not even stamped, it reveals the fault of all, especially of the grantee, also of the overseer." The rest of 112 is already given on page 205.

113. "To some pipes no ajutages were attached. Such pipes are called uncontrolled, and are expanded or contracted as pleases the water-men."[1]

114. "The following method of cheating practised by the water-men is, further, unbearable; when a water-right is transferred to a new owner they will insert a new ajutage in the delivery tank; the old one they leave in the tank and draw water from it, which they sell.[2] Most especially, therefore, as I believe, should the commissioner (*curator*) have in mind to stop this; for thus he will maintain not only the measure of the water itself, but also the good condition of the tanks, which get to be leaky when they are so often and unnecessarily tapped into."

Frontinus does not appear to fear a counterfeiting of the official stamp on the ajutages, which would be difficult of discovery, and could be detected only by comparing the granted diameters with the actual diameters; and this means of detection could be used without the use of an official stamp.

Neither does he say anything about, nor was he in a position to appreciate, some of the finer points of hydraulic practice made appreciable by centuries of experience, study, and practice since his time. Thus, it would make a difference in the discharge of the ajutage whether the same were tapped into still water or into a slow or swift current, even though tapped in perpendicularly to the line of the current, as he recommends. The head of the ajutage should, moreover, be exactly smooth and flush with the straight side of the water-course to be tapped, and have sharp square edges. As the level of the water varied in the cisterns or in the aqueducts, the discharge of the ajutages would necessarily vary with it. This level would vary more at some points than at others, so that owners of the same

[1] This word meant subordinate public waterworks officials.

[2] Refers to sale by measure (*amphora*). Mommsen, *Zeitschr. f. gesch. Rechtsw.* 15.

measure of water-right would not be able to draw the same quantities of water.

Then, again, the discharge of an ajutage one inch in diameter is by no means proportional to the cross-sectional area of the two ajutages when compared with the discharge of, say, a nine-inch ajutage. But Frontinus, as we have seen, compares even the discharge of an aqueduct with the discharge of the several ajutages supplied by it, by comparing the cross-section of the stream of water which the aqueduct carries with the sum of the cross-sections of the several ajutages supplied by it. In the light of modern knowledge all this becomes painfully absurd when uttered by so conscientious a writer as Frontinus. But thenceforth we can overlook that to him it is immaterial (27 and 28) whether a Roman citizen own twenty rights to insert a *quinaria* (the circular ajutage of about .632 square inches, English, in area) into a designated cistern, or the right to insert one *vicenaria* (twenty *quinariae*, about 12.6 square inches, English) in cross-sectional area, though the discharge in these two cases is now known to be materially different.

Let us here take up the much discussed question as to the quantity of water which constituted what Frontinus called a *quinaria*, and which was his unit of measurement for water in motion.

This determination of the quantity of water in a *quinaria* lies at the foundation of determining how much water was delivered to ancient Rome by its aqueducts, a question about which probably more nonsense has been written, or rather repeated or compiled, than about many another. The original sinner in this regard, as it has taken me many weary hours to discover, was Prony ("Mémoires de l'Académie Royale," Vol. II., A. D. 1817). Prony says that *if* we assume that the head acting on the *quinaria* ajutage was equal to its length, this being the custom in Rome in 1810 with respect to the "*oncia Romana*," and *if* we assume a discharge freely into the air, the value of a *quinaria* will be thus and so (about sixteen thousand United States gallons per twenty-four hours), being more than three times what it probably was, as I shall presently show. Every writer I have seen of a date since then except Blumenstihl and Belgrand,[1] and, worse than that, every

[1] And Belgrand had not the courage of his convictions, in making up his tables.

encyclopaediacal or other compiler since 1817, has ignored the two "ifs" of Prony; then, using Prony's conjecture as a fact, and otherwise exaggerating quantities, has stated the consumption in Rome to *have been* the enormous quantities we have all seen in print, namely, fifty million cubic feet, or three hundred and seventy-five million United States gallons, in twenty-four hours.

But these figures are absurd. To admit them would result in velocities in the channels and pipes so great that we know that they did not exist. There is no authority, on the other hand, for believing that the head acting on the Roman ajutages *was* in truth equal to their length, and we know that they did *not* discharge freely into the air. The discharge was out of delivery tanks or cisterns through long pipes to the places of water consumption, and can be approximately computed. Other methods of computation also may be employed to compute the value of a *quinaria*.

As we have seen, we can form a very close approximation to the maximum discharge of Marcia at the intake. And as Frontinus tells us that Marcia had at that point 4,690 *quinariae*, one might at first thought believe that the value of a *quinaria* could thus readily be arrived at. But the 4,690 *quinariae* are nothing but a measure of the area of the cross-section of the flowing stream where it had an acceptable or normal velocity. So that the most that we could learn would be that the *velocity* at that point and at the time had been considered by Frontinus as a normal or proper velocity of flowing water. We know that this velocity, the maximum at that point, was about 3.25 feet per second. So that we know that when a *quinaria* pipe measuring .632 square inch (English) was running at the rate of 3.25 feet per second, it was still discharging only a *quinaria* of water. Under the circumstances stated a *quinaria* was therefore about 9,250 United States gallons per twenty-four hours, equal to about .0143 cubic foot per second. Unquestionably it was still a *quinaria* of water when the velocity of the water was only two feet per second, and very likely when it was only one foot per second.[1] In other words, the value of a

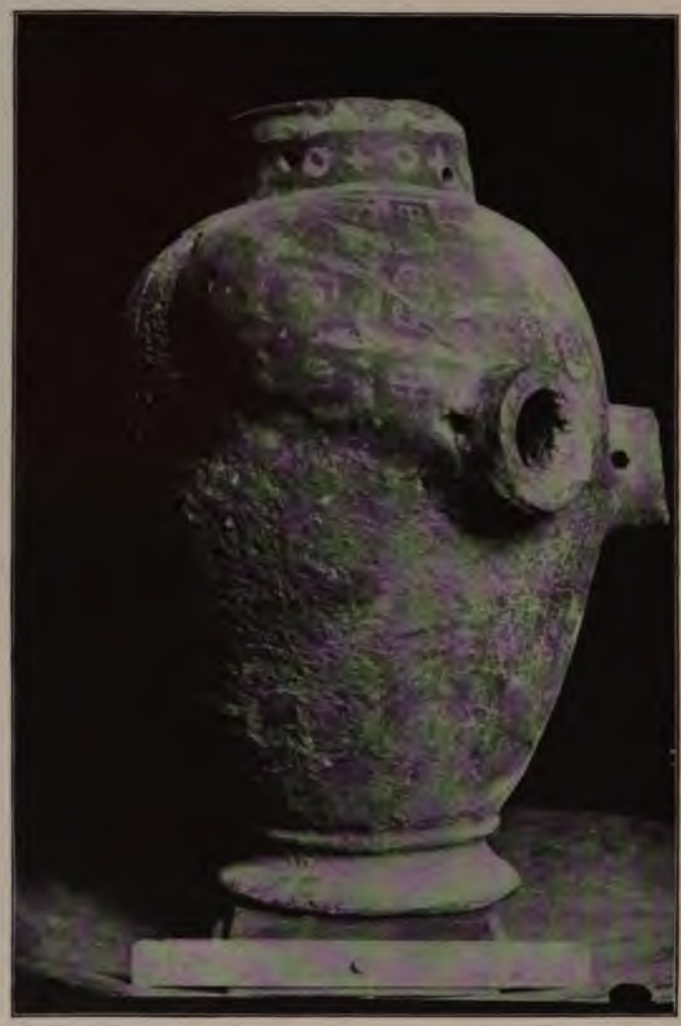
[1] The Roman aqueducts of Nîmes, Lyons, Metz, Antibes, and Arcueil, in France, have been much more carefully surveyed than those of Rome. The widths, depths of flow, and hydraulic gradients are known; and I find the velocity of flow of the water to have been 1 foot 2 feet, 1.33 foot, .2 foot, and 1 foot respectively.

quinaria ranged presumably, from about .0143 cubic foot per second, equal to 9,250 United States gallons per twenty-four hours, to .0044 cubic foot per second, equal to 2,850 United States gallons per twenty-four hours.

That these are not wild figures may be proven in another way. Let us suppose, to take the example given by Belgrand, a difference of level of twenty-three feet, and the point of efflux 670 feet from the cistern, as one reasonable supposition; and only seven feet difference of level at a distance of 170 feet, for another supposition, according as political or other influence, exerted with the commissioner, had put a cistern for the consumer in a more or less favorable situation for the consumer's use; also, suppose fifty feet of *quinaria* pipe at the end of the ajutage, as the law directed; then ignoring the Eytelwein experiments, I find that if a 15-pipe were carried from the end of the fifty foot length of small pipe to the point of efflux, either the twenty-three foot difference of level or the seven foot difference, the slopes being nearly the same (and because the exact discharge depends on the action of the Venturi part), will yield in the vicinity of 29,000 gallons per twenty-four hours. But if the *quinaria* pipe were continued all the way in each case, the discharge would be only 6,500 gallons and 7,100 gallons per day respectively.

So that while a *quinaria* ajutage could for purposes of theft be coaxed or misled into being worth 29,000 gallons per twenty-four hours, it would discharge lawfully only 6,500 or 7,100 gallons in twenty-four hours, under circumstances of discharge such as presumably obtained in a multitude of cases.

In a lecture on "Frontinus, and his II. Books on the Water Supply of the City of Rome, A. D. 97," which I delivered in February, 1894, before the Engineering Students of Cornell University, I found no better way to determine the value of a *quinaria* than by assuming that certain gaugings of the Marcia, Virgo, and Claudia springs, made in modern times, might be taken as equivalent to the discharge of these same springs in ancient times. Of course the discharge of springs varies with the seasons, but not enormously. Springs such as these are not liable to vary often so much as from 1 to 2, for example. At all events, taking Blumenstihl's gaugings, about 1869, of the three



TERRA-COTTA JAR.[1]

springs above-named, but ignoring the matter of leakage and theft between the springs and the city, gave the value of a *quinaria* in use in the city from out of these three aqueducts, as follows: —

Marcia,	13,700	gallons	per day.
Virgo,	6,400	"	" "
Claudia,	9,400	"	" "

[1] From the Etruscan Museum of the Vatican. Believed to be an apparatus for dividing a stream of water, no matter what its exact volume might be, into two equal parts. Note the small holes in the three necks of this terra-cotta jar for attaching lead pipe to the same. The scale is twenty centimetres, nearly nine inches long.

Virgo was a low-level aqueduct and must have leaked out but little. Possibly some water leaked in. Marcia and Claudia, on the other hand, were high-level aqueducts, with a large amount of loss by leakage.

It will be seen that the above three methods of determining the quantity of water which Frontinus called a *quinaria* produce results reasonably consistent among themselves.

A quinaria was about 5,000 *or* 6,000 *United States gallons per twenty-four hours, plus or minus* 2,000 *or* 3,000 *United States gallons, according to circumstances, favorable or unfavorable.* It made no pretence of being an exact measure. Had it been more exact, a great deal that seriously troubled Frontinus would have been explained. But then, on the other hand, it would in that case have been some 1700 years ahead of its time, and Frontinus would in all likelihood have had "no use for it," as goes the phrase of to-day.

CHAPTER VI

HYDRAULICS AFTER FRONTINUS' TIME

Nil sine magno
Vita labore dedit mortalibus.

HORACE (65—8 B. C.),
Satires, i. 9, 59.

Life has given nothing to mortals without great labor.

TO appreciate Frontinus' position with regard to a proper knowledge of the velocity of efflux, and generally of the velocity of running water, it is instructive to follow the development of the art from his time until we arrive at the formula $v = \sqrt{2gh}$, now known to every beginner in hydraulic science, and the very foundation-stone of that science as it is known at the present day.

This formula, and the numerical values it gives to velocities of efflux, was not discovered until about the year 1738, when Daniel Bernouilli and John Bernouilli, his father, each published a different mathematical demonstration of this law. It thus appears that Frontinus wrote some 1640 years before this fundamental fact was known. By mere number of years in anticipation, he was therefore as much in the dark respecting numerical values for velocity of efflux, as we are concerning the latest discovery in hydraulics that will have appeared in the year 3538; and even by making due allowance for the greater rate of speed with which discoveries are now made, compared with ancient times, he was as far in anticipation of the year 1738, as we are of the year 2300, or 2400. "Better fifty years of Europe," says the poet, "than a cycle of Cathay," and Frontinus' time just preceded a cycle of stagnation, and even of retrogression, compared to which Cathay may be said to progress with reasonable celerity.

During 1200 years after Frontinus, practically no progress was made in the arts and sciences. The first awakening to a new life, to a revival of learning, may be dated from Roger Bacon, 1214–1293, who

preached the importance of experiment, and declared knowledge in his day to be but in its infancy. We who have been educated in English-speaking countries have been accustomed to consider Lord Francis Bacon, 350 years later (1561–1626), as the author and apostle of the experimental method of studying science. But he himself made no experiments of any note, and modern research shows him to be entitled to the latter credit, only as he influenced his countrymen of Great Britain. Because a hundred years before his time lived that remarkable painter, sculptor, teacher, and engineer, Leonardo da Vinci[1] (1452–1519), the misfortune of whose fame it has been that his voluminous works, hidden away for centuries in private keeping, and exposed to manifold vicissitudes, found no publisher until the last few years; and have, even to-day, not been before the public long enough to be used by modern writers as they undoubtedly will be. He not only preached the duty of study by means of experiment, but was himself a most prolific experimenter, and a teacher. In the last named way, he anticipates Lord Bacon; in the other, he is the forerunner even of Galileo. This is what he says on the first-named subject:—

"In the examination of physical problems I begin by making a few experiments, because it is my desire to state the problem, after I have had the experience of it, and then to show why it is that the bodies are forced to act in the described manner. This is the method it is necessary to follow in all examinations concerning the phenomena of nature. It is true that nature begins, as it were, with argument and ends with experience, but nevertheless we must follow the contrary way; as I have said, we must commence with experience, and strive by means of it to discover truth.

"In the study of the sciences which are allied to mathematics, those who do not consult nature, or authors who are not the pupils of nature, are merely little children. I say it emphatically. Nature alone is the true teacher of true ability. And yet, behold the stupidity of it! The world makes merry over a man who prefers to learn from nature rather than from writers who themselves could only be the pupils of nature."

[1] Grothe, Hermann, *L. da Vinci als Ingenieur*, etc., Berlin, 1874.

His experiment on the law of falling bodies is most interesting in connection with the matter we are now considering.[1] He used two long boards hinged together like the leaves of a book. On the inside these boards were smeared with tar or wax. A string latch served to close them suddenly. He then takes a small tube, filled with shot, the tube having nearly the same diameter as the shot. This tube is held vertically in and over the angle of the wooden book, itself set up vertically. The shot are then allowed to drop out, and on pulling the latch are caught, as they fall between the leaves of the wooden book; and their relative distances, as they are falling, are impressed on the tar or wax covering of the boards.

Until quite recently Galileo has been supposed to have been the first experimenter on the laws of falling bodies, but here was this great engineer and teacher busily at work at it one hundred years previously. However, with Galileo (1564–1642), we first touch the modern science of "dynamics," or of bodies in motion. Says Rühlman:[2] "For the proper founding of the science of dynamics, or of the science which treats of the causes and the laws of motion, were requisite talents of a degree of eminence, such as the Lord Almighty called into being with Galileo in the year 1564."[3] But Galileo had no proper means for measuring time, no clocks or watches. Both he and his son tried to make a clock but did not succeed. Instead, he used a large bowl of water, having a small orifice at the bottom, and compared times by the weights of water discharging during these times; using his finger to start and stop the flow of water out of the bowl. As we shall see, it is a reasonable assumption that this makeshift of a clock became, in the hands of Galileo's pupils, and of those of his pupil's pupil, the suggestion for an experimental demonstration of the laws of efflux in general.

Castelli (1577–1644), the pupil of Galileo, was a Benedictine monk, from that same Montecassino which saved Frontinus' commentary to posterity, and he first showed that the quantity of efflux, in a given

[1] Da Vinci, Leonardo, *Del Moto e Misura dell Acqua*, Bologna, 1828, p. 364.

[2] *Gesch. d. technischen Mechanik*, p. 53.

[3] Libri, *Histoire des Sciences Mathématiques*, iv. 160, 466, gives proof positive that Lord Francis Bacon knew Galileo's work, published and unpublished, a year before the publication of the *Novum Organon*. See, also, Hume, *History of Great Britain*, 1770, iv. 215.

time, depended by law on, or was a function of, the depth of water in a bowl such as the one just spoken of; that is, was a function of the head. But he wrongly stated this law, making the quantity vary directly as the head. It was his pupil, Torricelli (1608–1647), the inventor of the barometer, the grandson, in a professional sense, of Galileo, who first proved, in 1644, or only two years after Galileo's death, that the velocities of efflux are as the square roots of the head. But this still furnished no numerical value for the velocity of efflux. Still another, and still other great men, had to devote their lives to this cause; thirty more years had to pass by, till Huygens (1629–1695), the inventor of pendulum clocks, first found the numerical value of the acceleration of gravity, commonly represented by the letter g, in 1673; and sixty-five more years had to elapse, until the genius of the two Bernouillis, father and son, in 1738, or two hundred and fifty years after Leonardo da Vinci, finally laid the foundation of modern determinate hydraulics, by writing the equation of $v = \sqrt{2gh}$, every letter and character of which may be considered the contribution of, and a tribute to, the skill and perseverance of one or more of the many great men that have been named. v may stand to symbolize the experiments of da Vinci and of Galileo, and the preaching of the two Bacons; $2g$ alone would suffice to immortalize Huygens, were he not already permanently distinguished by his invention of pendulum clocks and other works; h may serve to recall Castelli; and the square root sign, his pupil, Torricelli; and when next we write the formula, let us remember that it took two hundred and fifty years of work, not to speak of another and a preceding two hundred and fifty years or more of speculation, to put it upon the blackboard of the world. But no amount of speculation alone, or of peripatetic philosophy, would have produced it. To do that, the work of centuries of earnest men, not too proud to dip their hands into bowls of water, and to *experiment* in hydraulics, the while they were wearing mechanic's overalls, so to speak, was absolutely necessary.

No wonder then that Frontinus, who lived in an age of peripatetic philosophy, did no better than we have found in his two books, in the way of gauging the water supply of ancient Rome.

CHAPTER VII

ARITHMETIC, A. D. 97, AMONG THE ROMANS

. . . 'Dicat
Filius Albini, si de quincunce remota est
Uncia, quid superat? — Poteras dixisse.'
'Triens.' — 'Eu!
Rem poteris servare tuam! — Redit uncia; quid fit?'
'Semis.'

HORACE (65-8 B. C.), *Ars Poetica*, 325.

'Let Albinus' boy say, if from a five-twelfth an ounce be taken, what will remain? You know.' 'A third.' 'Very good! You'll be able to take care of your property! If an ounce be added, what will it make?' 'A half.'

ONE of the astonishing things noted in reading the book of Frontinus is the readiness with which he performs his arithmetical computations, without knowing anything of the Arabic or Indian system of notation, or of common or decimal fractions. To him fractions are entities having names, and represented by hieroglyphics. They have certain relations to unity, and to one another, indeed, but just how he keeps track of them all, and manages to use the lot, is as great a puzzle as the Chinese alphabet, which his set of fractions in some respects resembles.

After the first four of the larger fractions, they are all of the duodecimal order, the list being as follows: ½, ⅓, ¼, ⅙, 1/12, 1/24, 1/36, 1/48, 1/72, 1/288, with a name for each one. (Semis, Triens, Quadrans, Sextans, Uncia, Semuncia, Duella, Sicilicus, Sextula, Scripulus.) There are also symbols and names for 5/12, 7/12, ⅔, ¾, 10/12, and 11/12. The division by twelve dates back, as is known, to a period of great antiquity, and has come down to us in the twenty-four hours of the day, and in the sixtieths of the hour, and the sixtieths of that, as used, together with duodecimals, by the Greeks; who, according to Herodotus, learnt them of the Babylonians,[1] the sixtieths being the modern minutes and seconds,

[1] Herodotus, ii. 109.

originally called "*partes minutae primae*" and "*partes minutae secundae.*"[1]

The relation of the circumference and the area of the diameter of a circle is given by Frontinus with the use of $\pi =$ as near $3\frac{1}{7}$, = about 3.1429, as the use of the clumsy fractions, just named, selected and added up, will permit of. Working with duodecimal fractions, it would have been far easier to take $\pi = 3\frac{1}{8}$, as had been done by Vitruvius,[2] only one hundred years before Frontinus. But he laboriously ploughs along with $\pi = 3\frac{1}{7}$,[3] and is always pretty nearly right: — except when he, or some copyist, or translator, or printer, has made a mistake; which is not without example.

CALCULATOR.[4]

Thus, he tells us, the *quinaria* has an interior diameter of one digit and three unciae; or, as we should say: 1.25 digits, the digit being $\frac{1}{16}$ of a foot; "in circumference, three digits, a half, five unciae and three scripuli;" or, as we would say: 3.92709 + digits. Calculated on the basis of $\pi = 3\frac{1}{7}$, this figure would be 3.9285 +, and for the ordinarily used value of $\pi = 3.1416$, it is 3.9270.

His areas are $\frac{\pi d^2}{4}$ and he well knows that the areas are as the squares of the diameters. But when it comes to the conception of a cubic foot, he seems to avoid it, and appears to be in total ignorance of so much as a conception of the idea of a procession of such cubic feet passing a given point in a unit of time; or of what we ordinarily call cubic feet per second; in which respect he is equalled, however, as we have seen, by many men, some of them of considerable standing in the community, who are living at the present day.

Frontinus ascribes the name *quinaria* to the diameter of the finished pipe, being five quarter digits in diameter;[5] and he goes on call-

[1] Cantor, *Gesch. d. Math.* i. 445. [2] *Agrimensoren*, 88.

[3] *De Aquis*, 24. Also, J. Assoc. Engineering Societies, June, 1909.

[4] The ancients counted by means of small stones (*calculi*). The mathematician represented here, from a gem in the *Cabinet de France*, No. 1,858 of the Chabouillet Catalogue, arranged the *calculi*, while the reckoning tablet, covered with Etruscan characters, is in his left hand. Daremberg et Saglio, *Dict. des Antiq. grecq. et rom.*, under the word *Abacus*.

[5] *De Aquis*, 25.

ing a pipe of six quarter digits in diameter, a *sextaria;* and so on, only that at twenty quarter digits in diameter it becomes nearly the same, whether the name *vicenaria* be ascribed to quarter digits diameter, or to square digits of area. From this size upwards he names the pipes by their areas in square digits, stopping at a pipe of one hundred and twenty square digits area, nearly nine inches in diameter.[1]

[1] Pliny (xxxi. 31) and Vitruvius (viii. 6, 4) name the pipes by their circumferences, instead of by their diameters, as is now customary. Rope is sold by circumference measure at the present day.

CHAPTER VIII

THE DISTRIBUTION SYSTEM

Comes facundus in via pro vehiculo est.
PUBLILIUS SYRUS (abt. 50 B. C.), 104.
A talkative companion is as good on the way as a wagon.

BEGINNING Book II. (Chapter 64), Frontinus takes up the distribution system of the City of Rome in his day, until, in Chapter 87, we have another one of his favorite exclamatory passages, expressing satisfaction with what has been and still is proposed to be done for his pet, the "Eternal City." We have commented, up to this point, upon the aqueducts, from their sources down to their entrance into the city, and may now see what became of the water they carried.

The aqueducts ended at various points and at various elevations within the city, generally in form of a cistern or delivery tank, called a *castellum.* Thence were laid lead pipe to other cisterns, for public and for private consumers, to fountains, water-basins, and elsewhere. Thus, *castra* were the military camps, or barracks; *opera publica*, the public buildings or other structures, exclusive of those belonging to the emperor, — the water supplied to these last was termed *in nomine Caesaris. Lacus* and *salientes*[1] were public basins and jet-fountains; *munera* were the large ornamental fountains; *beneficia Caesaris* were the imperial grants to private consumers. Says Frontinus: 115. "This mode of gaining money practised by the water-men is also to be abolished, the one called 'tapping.' Far away, and in all directions, run the pipes under the city pavements. I discovered that these pipes were furnishing water by special branches to all whom they passed and who had been able to arrange[2] for it; being

[1] Middleton, ii. 349–350.

[2] The Tammany equivalent, 1898, for this word "arrange" would be "to see" the water-men.

bored for that purpose here and there by the so-called tappers; whence it came that only a small quantity of water reached the places of public supply. The amount of water gained in consequence of our abatement of this evil I measure by means of the fact that we have gathered a large quantity of lead by the removal of that kind of branch pipes." This gives a vivid picture, incidentally, of the common and extensive use made of lead pipe at the time.

These lead pipes have been dug up literally by the ton. So late as 1878, Prince Torlonia melted down a ton of them dug up on his land alone. But in so doing he deprived modern antiquarians of a great treat.[1] Prof. Rodolfo Lanciani, of Rome, has made a special study of these Roman lead pipes, and by means of the inscriptions in raised letters ordinarily found upon them, and evidently produced by engraved rollers used in rolling the lead plates out of which the pipes were made, has been led to make some curious discoveries.[2] He has located by means of them the residences of some eighty or ninety distinguished citizens. He also finds that there were female plumbers in ancient Rome, as well as female householders; but, as a lady wittily remarked on hearing this, whether a female plumber in ancient times was any more reliable than the male plumber of modern times the records so far discovered do not say. Presumably these female names signify the owners of plumber shops operated by slaves.

The list of names of these artificers would lead one to suppose that their lines had fallen in pleasant places. "The Fortunate One," "The Happy One," "Happiest of All," "The Hilarious One," "Skilful One," "Flourishing One," "Of Beautiful Form," are some examples. Christian plumbers of that time may also be distinguished occasionally from their pagan brethren.

The rule is that on one side these pipes hold the name of the proprietor, or rather life-lessee of the right to draw water through that pipe, while on the other side is the name of the plumber who made it.

The fact that the water-right had been granted by an emperor was frequently marked on the pipe; and when it had been a gift from the emperor, this was noted by means of the words *ex liberalitate.*

[1] Middleton.

[2] Henzen, *Ann. Inst.*, 1864, p. 6; Mommsen, *Bull. Inst.*, 1866, p. 127; Middleton. ii. 331, 335.

The numbers cast on the pipes have long puzzled the antiquarians. They do not represent sizes or stations. So much has been determined. Perhaps they are mere shop numbers, serving to distinguish and identify the several lengths, and to bring home responsibility in cases of failure of the pipes at any point, — just such numbers as are now cast on cast-iron pipe lengths. In Rome such pipes have been

LEAD AND TERRA-COTTA PIPE.[1]

found up to twenty-seven inches diameter; also up to nearly one and one quarter inches in thickness when only five inches in diameter.[2] Ancient Roman shears to cut sheet-lead, made precisely like tinsmith's shears of the present day, have been found in Rome.

As already stated, these lead pipes were made by bending lead plates, of the proper width, and some ten feet long, into a pear-shaped cross-section, or like an inverted capital letter "omega," then soldering the longitudinal joint. The solder used was pure lead. That

[1] Collection of lead and terra-cotta pipe in the Magazzino Archeologico at Rome. From a photograph taken by the author.

[2] Lanciani, *The Ruins*, etc., pp. 186, 434, 531.

used in pipes dug up in Lyons, in Paris of the second century, as well as that used in Pompeian pipes, contained not a trace of tin.[1] I have been unable to find when the modern method of soldering with an alloy of tin and lead, and with copper points, first came into use, or when lead pipes were first made without a seam, by cold drawing, or by

LEAD PIPE, STOP-COCKS, AND FOUNTAIN FIGURES IN THE GARDEN OF THE HOUSE OF VETTI, POMPEII.[2]

the hot method now used.[3] Belgrand, a noted French engineer, caused a lead pipe to be made in imitation of the Roman method of bending the lead plate into a pear-shaped cross-section, and soldering it by pouring

[1] Belgrand. Lead pipe laid for Cardinal Wolsey between 1515 and 1530, and dug up in 1898, are soldered; "seam and joint were made by an overlay."

[2] From a photograph taken by the author. More than twenty of these little fountain figures in this garden, with water properly "laid on" to each of them.

[3] Pliny, *Nat. Hist.* xxxiv. 48, gives the recipe for solder: two parts lead + one part tin. Belgrand, p. 70.

melted lead on the joint. He found on testing it, the plate being about one fourth inch thick, and the pipe, when rounded, about four inches in diameter, that at 45 pounds pressure the pipe began to assume a circular section; at 112 pounds it was a circular pipe; and it failed at 250 pounds, without failing at the joint.[1]

Sometimes these lead pipes were laid in subways, instead of being buried in the ground. A notable example was the lead pipe that fed

LEAD PIPE LAID IN THE STREETS OF POMPEII ON THE SIDEWALKS.[2]

Meta Sudans, a large fountain near the Colosseum, whose brick core remains and forms a prominent landmark in front of the Arch of Constantine.[3]

In Pompeii, the lead pipes are, as a rule, not buried in the ground. In the garden of the house of Vetti, the lead pipes and branches to the twenty or thirty little fountains it contained, with their little plug-cocks in each branch, are still in place, as also the main pipe laid in the gutter that surrounds the garden. In the streets, they are laid on the

[1] For wooden and stone water-pipe in Rome, see Middleton, ii. 327; and Lanciani's *Frontino*. The figure on p. 190 shows stone water-pipe.

[2] From a photograph taken by the author.

[3] Lanciani, *Frontino*, 414.

sidewalk, in the angle formed by the sidewalk and the houses, and are run under the steps leading to the houses.

Methods of hydraulic construction are very different in countries that need not provide at all or only partially against frost, from what they are in northern latitudes. The winters of Southern Italy make possible in Naples and in Rome what would be impossible in many other cities and countries.

THREE-INCH PLUG-COCK, BRONZE-PIPE ELBOW AND T, AND LEAD PIPE.[1]

Four-way branches, brass stop-cocks, wipe joints, bronze bath-tubs as well as marble ones, in short, all the essentials of the outfit of a modern plumber's shop, have been recovered in large quantities, and may be seen in the museums of Rome and of Naples. And then to talk of the Romans as not having known that water rises in one leg of an inverted siphon when water is poured into the other!

In Chapter 76, at mention of Caelius Rufus we get another one of those glimpses of life in ancient Rome and of its actors, given by

[1] Magazzino Archeologico at Rome. From a photograph taken by the author.

Frontinus, that might readily make the starting-point for extended study, or for a book, if one wished.

This Caelius Rufus[1] was a typical Roman character of his age, though his short but brilliant life extended only from 85 to 48 B. C. The pupil of Cicero; the lover of Clodia, who in turn was the beloved of the poet Catullus and the subject, the Lesbia, of many of his verses;

MARBLE BATH-TUB.[2]

defended by Cicero in one of his most famous speeches, *Pro Caelio*,— this one name brings to our mind an array of noted personages and their doings, that is sufficient to cause the dead times of those

[1] Tyrell and Purser, *The Correspondence of Cicero*, iii. 38.

Boissier, *Cicéron et ses Amis*, contains a humanely written chapter on Caelius. Boissier fully appreciates that it is as mistaken a process to attempt to judge of either the defendant or the plaintiff from the plea of the lawyer of either side when made in ancient times, as it would be to attempt to form such a judgment from a similar plea made to-day. Yet many a writer is constantly doing this very thing, and on all sorts of subjects. What is the warning that Cicero gives on this point (*Pro Cluent.* 50)? "It is a mistake to suppose," says he, "that our orations contain our personal opinions; they are the language of the case and of the circumstances, and not that of the man and of the orator."

Drumann, *Geschichte d. Röm. Repub. im Untergange.*

[2] In the garden of the Magazzino Archeologico at Rome. From a photograph taken by the author. Many other and finer specimens are in the Vatican.

far-away years seemingly to live again, as though they had been but of yesterday.

"Everything in Rome is now dead as dead can be," writes Caelius to Cicero, about 50 B. C. "Were I not here to stir up the shop-keepers and the water-men, a complete lethargy would now rest upon the commonwealth."

CASE OF STOP-COCKS, FOUNTAIN HEADS, AND OTHER INTERIOR WATER FIXTURES,[1]
IN THE MAGAZZINO ARCHEOLOGICO AT ROME.

Caelius no doubt did it well; we may take Frontinus' word for that: but his speech "Concerning Waters," though known to Frontinus some one hundred and fifty years after it was delivered, has unfortunately not been preserved to us.

I have above spoken of the number of fountains in the little garden of an ancient house at Pompeii. This profuseness of constantly running water is characteristic of all southern methods of hydraulic construction, and cannot on account of snow and ice be similarly followed

[1] From a photograph taken by the author.

in northern countries. It has remained typical of the Roman system of water-supply down to the present day, and nothing can look more shiftless and out-of-place to an engineer from the New England States than

CASE OF STOP-COCKS, AND OTHER INTERIOR WATER-FIXTURES,[1] IN THE NAPLES MUSEUM.

to see the post hydrants in the streets of Rome running as they do (1897), night and day, into the gutter. The distribution of water for domestic purposes in modern Rome is, similarly, based on a continuous flow of water, just as it was in ancient times. I had the pleasure of seeing

[1] From a photograph taken by the author; unfortunately under very unfavorable circumstances.

the interior of a modern *castellum* on the *acqua Felice*,[1] and it may have differed very little from an ancient *castellum*. A lead pipe, say three inches diameter, carried the water from the adjoining masonry aqueduct into a small box or tank; out of this led five or six smaller pipes, though not all of the same diameter, to the consumers' premises. The water was kept at a uniform height in the little tank by means of

ANCIENT ROMAN FOUNTAIN-HEAD AND TROUGH.[2]

a stop-cock and an occasional visit of the *aquarius;* and the proprietors, whose names were painted on a board hung up against the wall, owned the right to have the water flow continuously out of the tank through these pipes of designated diameters.[3]

When we take up the subject of fountains, public and private, in ancient Roman times, an overwhelming mass of materials for descrip-

[1] In company with engineer Prof. D. Spataro of Rome, to whom my thanks are here gladly expressed.

[2] Restored to use in the garden of the Magazzino Archeologico in Rome. From a photograph taken by the author. The keeper and his family are guarding it.

[3] *Castellae* of the waterworks of Pompeii may yet be seen. Some years ago one was found in Rome. "I thought it was an organ," quoth the semi-intelligent uncoverer and discoverer of this archaeological treasure; and he immediately proceeded to knock it to pieces — for the lead there was in it for him.

tion and discussion presents itself. Artistically, also, this field, as one might expect, is exceedingly rich, offering opportunity, as it does, to both the sculptor and the architect. Pliny the Younger, the friend

COURT-YARD OR GARDEN FOUNTAIN

FROM THE HOUSE OF THE BEAR, AT POMPEII.

of Frontinus, and a man of wealth, describes in one of his letters[1] his villa near the seashore. Speaking of one room he says: —

"At the end is a marble couch covered with a trellis, and supported on four columns of Caryst marble. Water escapes from out

[1] *Epist.*, v. 6.

of this couch as though pressed out by the weight of him who rests on it. Small pipes lead it to a stone channel; thence it is received in a marble basin, whence it escapes by hidden channels, so arranged that

COURT-YARD OR GARDEN FOUNTAIN,
FROM THE HOUSE OF THE GREAT FOUNTAIN IN POMPEII.

the basin is always full, but never runs over. To take a meal in this place, the main dishes are set on the edge of the basin, and the others float in baskets fashioned like little ships, and like water-fowl, and through two openings which connect, it falls and ascends again continually. At one side is a fountain, which discharges and receives

water at one and the same time; for the water, after spouting forth, falls back upon itself."

This description is not as clear as it might be, but I imagine the fault does not lie with the translators, but rather with Pliny himself, whose knowledge of applied hydraulics need not necessarily be supposed to have been extensive or acute. It reveals to us, however, a

STREET FOUNTAIN AND WATERING-TROUGH IN POMPEII.[1]

skilful disposition of spouting and of flowing water as a means of household or interior decoration. Many more such examples could be given, culled from literature, wall paintings, or from the ruins of the fountains themselves. I give a few examples from Pompeiian interiors, from the streets of Pompeii, the Meta Sudans as engraved and chiselled, and its remains as now to be seen near the Colosseum in Rome. Bronzes, also, are very numerously and richly represented among the remains of Roman fountains. A tiger's head was a

[1] Called from the figure that spurted water, the fountain of Mercury. From a photograph taken by the author. Note the hollow worn in the edge of the hard stone tank by the hands of those who leaned on it to take a drink.

STREET FOUNTAIN AND WATERING-TROUGH IN POMPEII.

Called the Fountain of Plenty, from the figure with horn of plenty on the perforated upright post.

favorite mouthpiece for water-jets. Dozens of them are now to be seen in the Museum at Naples, besides many entire pieces of statuary, human figures as well as birds and animals. A favorite device for small interior fountains in Rome seems to have been an inclined plane made in form of a marble slab with ridges cut on it, on which the water was caused to ripple and gleam as it flowed over; these

RUINS OF THE *META SUDANS*.[1]

slabs reminding one of that well-known utensil of American domestic economy, called a washboard. Many such slabs may be seen in the museums of Rome; sometimes the complete fountain. But this subject is an endless one, and I am forced to refer for an extension of

[1] A noted monumental fountain near the Colosseum. From a photograph taken by the author. In the background the arch of Titus, and on the right the temple of Venus and Rome. The central circular hollow is twenty-seven inches in diameter, and no doubt contained the lead pipe that fed the fountain. Being situated on low ground it offered every facility for a fine display of water-jets. Seneca (4 B. C. — A. D. 65) says, *Ep.* lvi, 5, that near this fountain was the place where people went to practise on bugles and flutes: and apparently the habits of a people are not easily changed, for we find the buglers of the Italian army thus using the vicinity A. D. 1897. This fountain thus built, prior to A. D. 65, was probably reconstructed several times. Lanciani, *The Ruins*, etc., 193, or Middleton, ii. 349.

these remarks to the few photographs I was able to take or collect of ancient fountains and their furniture.

We are now ready, with some intelligence, to grapple with the much-mooted and befogged question as to how much water was delivered into ancient Rome A. D. 97, for the consumption of about a million people;[1] that old question of the encyclopædias, upon which the public stands in need of enlightenment, but gets only, unchanged from edition to edition, the same wonder-evoking narrative. It can

META SUDANS.[2]

get no other, so long as these replies continue to be produced by what a gardener would call "propagation from sprouts."

The true answer can be readily given so soon as we have determined what was the average discharge of the thing Frontinus calls a *quinaria*. I say average, for it must have had, as we have seen, many values, ranging from some 2,500 to 9,000 gallons per twenty-four hours.[3] To

[1] The estimate of Professor Beloch, endorsed by Lanciani.

[2] From a large brass of Vespasian (A. D. 69–79) kept at the British Museum. Donaldson's *Architectura Numismatica*, p. xxx. and drawing No. 80. *Meta Sudans* is also shown on other coins, for example on one of Titus (A. D. 80) described as No. 184 on p. 362, Vol. I. of Cohen, *Monn. Imp.*, and drawn on one of the plates, which shows it to the left of the Colosseum, the central figure on the coin. So also No. 79 of Donaldson's *Arch. Numism.*

[3] See p. 215.

be liberal let us call it 6,000 gallons per twenty-four hours; less than one-hundredth of a cubic foot per second.

We then have the following table: —

Name of Aqueduct.	*Quinariae* actually set and in use as given by Frontinus.	Discharge in United States gallons per 24 hours.
Appia	704	4,224,000
Anio Vetus.	1,610	9,660,000
Marcia	1,935	11,610,000
Tepula	445	2,670,000
Julia	803	4,818,000
Virgo	2,504	15,024,000
Alsietina	392	2,352,000
Claudia	2,812	16,872,000
Anio Novus	2,813	16,878,000
Total	14,018	84,108,000

That is, there were some eighty-four million gallons distributed within and without the city walls, when the nine Frontinian aqueducts were all running. Of this quantity, about fifty-four million gallons were distributed within, and about thirty million gallons without the city. But, we know, from Frontinus' account, as well as from Pliny, that for long periods of time one or more of these aqueducts did not bring water into Rome. For two reasons: the frequent necessity of making repairs upon them, of which I intend to speak later; and because, as the wise it call, their waters were diverted; we will say taken unlawfully, or, perhaps, call it stolen. This is what Pliny says on the subject:[1] "And yet for this long time past the pleasure of drinking these waters (Marcia and Virgo) has been lost to the city, owing to the self-seeking and avarice of certain persons who have turned them out of their course for the supply of their country-seats, and of various places in the suburbs, to the great detriment of the public health."

Taking out Marcia, Julia (which also was a special prey to thieves), and Virgo, we have remaining within the city only about thirty-eight

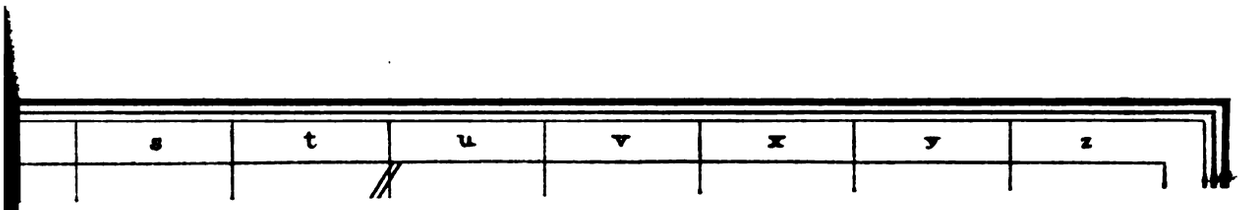
[1] *Nat. Hist.*, xxxi. 25.

million gallons; to which measure has shrunk Rondelet's unfounded but grandiloquent figure of nearly four hundred million gallons per day. Thirty-eight million gallons one day with another, is, however,

META SUDANS, AS REPRESENTED ON A WELL CURBING IN THE VATICAN.[1]

to the best of my conclusions, a fair estimate at which to set the water-supply within the walls of ancient Rome A. D. 97; though the total ranged, no doubt, some twenty million gallons per day either side of

[1] On either side is a figure of a lion devouring a horse, and a keeper of the beasts of the arena. From a photograph taken for the author. *Meta* was a pyramidal or conical goal in a circus, shaped like this fountain; and *sudans*, sweating, referred to the exudation of water from the fountain, either while it was still in running order, or after it had become a ruin with water oozing from it.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that mark, from time to time. This would make about thirty-eight gallons per day per inhabitant, which is still a very large figure, when use alone, not waste, is taken into account; and when, further, we

SMALL FOUNTAIN FOR AN INTERIOR.[1]

consider that by far the greater part of the people undoubtedly used only such water as was carried to their homes in jars on the heads of slave and other women.

[1] Small fountain for an interior, and on the left large fountain-head, in the Magazzino Archeologico at Rome. From a photograph taken by the author. The figure of a frog on the curbing of the fountain was also a fountain-head.

CHAPTER IX

OPERATION

> Aequam memento rebus in arduis
> Servare mentem.
>
> HORACE (65–8 B. C.), *Odes*, ii. 3.
>
> Remember to maintain a well-balanced mind in the difficult affairs of life.

CHAPTERS 89–93 and 112–130 (the end) are taken up with a portrayal of the practical difficulties encountered in the operation of the waterworks of Rome, A. D. 97.

Whatever Frontinus may have lacked in knowledge of the laws of hydraulics, certain it is that he takes high rank, even to-day, as an administrator, or practical superintendent of waterworks. His own language describing the operation of the Roman waterworks is the best illustration of this.

9. "Near the intake of Julia is a brook called Crabra. Agrippa disdained to take in this brook, either because he did not consider it of good quality or because he thought he was under obligations to leave it for the use of the proprietors at Tusculum; for it is the same which is distributed by turns, on fixed days, and in determined quantities, to the estates of that part of the country. But without the same moderation, our water-men constantly drew upon the greater part of it for increasing the flow in the Julian aqueduct, though not for the purpose of increasing the discharge of this aqueduct, which on the contrary they exhausted, by diverting its waters to their own profit. I therefore cut off the Crabra Brook, and gave it again entire, upon the orders of the emperor, to them of Tusculum; who perhaps now get it with great astonishment on their part, and without knowing to what cause to ascribe the unusual abundance. The Julian aqueduct, on the other hand, has regained its normal quantity, and holds it even during notable droughts, by reason of

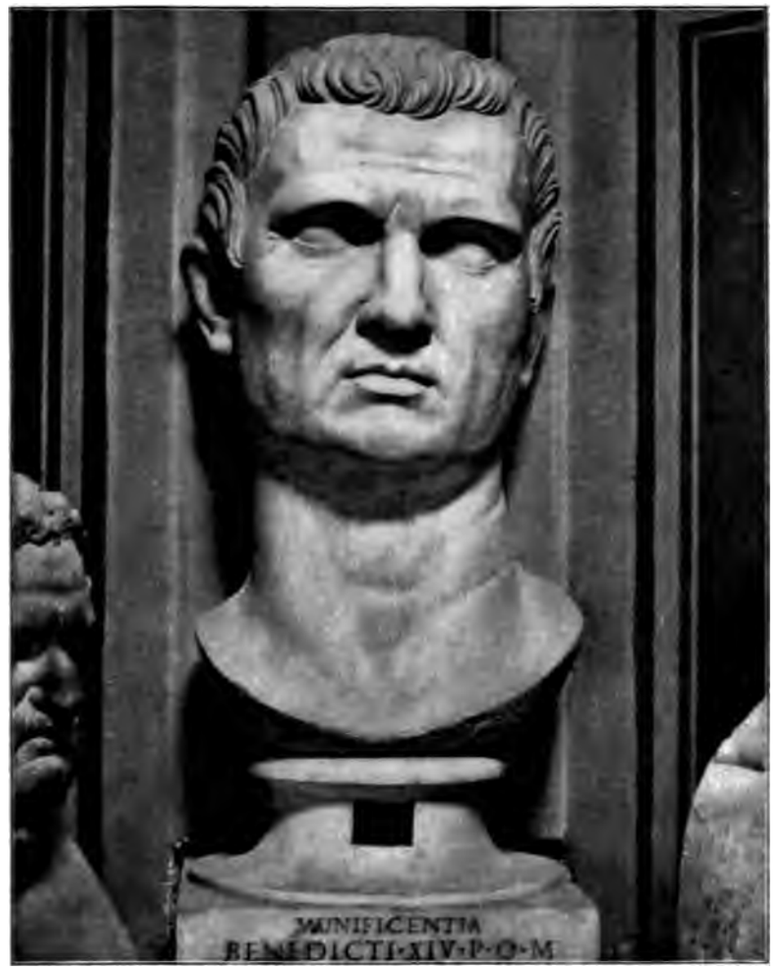
the destruction of the branch pipes, through which it was secretly despoiled."

87. "This is the schedule of the amounts of water distributed or available, down to the time of the Emperor Nerva (Trajanus). But now, by the foresight of the most painstaking of sovereigns, whatever had been unlawfully drawn by the water-men or had been wasted as the result of official negligence, has been recovered; this was practically equivalent to the finding of new sources of supply. And in fact the supply was almost doubled, and was distributed so carefully thereafter, that wards which had previously been supplied by only one aqueduct now received the water of several;" and so on, showing that this was done to keep all the wards supplied, no matter which particular aqueduct might, for the time being, be drawn for purposes of cleansing or repairs. For the same reasons, also, the running fountains were connected by lead pipes, each one generally with at least two delivery tanks, the two tanks being supplied by different aqueducts.

88. "The effect of this care displayed by the Emperor Nerva, most patriotic of rulers, is felt from day to day by the present queen and empress of the world; and will be felt still more in the improved health of the city, as a result of the increase in the number of the tanks, reservoirs, fountains, and water-basins. No little advantage accrues also to private consumers from the increase in number of private grants; and those who with fear drew water unlawfully, draw their supply now free from care, by grant from the sovereign. Not even the waste water is lost; the cleanliness of the city, too, is greatly improved; the air is purer; and the causes of the pestilence, which gave the air of the city so bad a name with the ancients, are now removed."

89, 90, 91, 92, 93 treat of a separation of the waters of the several aqueducts, in the uses to which they were put, by allotting them with reference to the qualities of each water. Some waters were mixed by reaching the city for part of the distance in one and the same aqueduct channel; "so that we have found even Marcia, so charming in its purity and coldness, used for baths, fulling-mills, and I may not say what vile appointments."

98. "The first permanent water commissioner was M. Agrippa (B. C. 34). He, as one might say, was commissioner mainly of works which he himself had called into existence. This was after his aedile



AGRIPPA (63–12 B.C.) SON-IN-LAW OF CAESAR *AUGUSTUS*, AND HIS RIGHT-HAND MAN.[1]

ship; and before his aedileship had come his consulship. Inasmuch as the amount of water now available warranted it, he determined how much should be allotted to the public structures, how much to the

[1] Perhaps the greatest of Roman builders. First *curator aquarum* of the city of Rome The man who probably was the principal instrument for changing Rome "from a city of brick to a city of marble" during the reign of Augustus.

basins, and how much to private parties. He also kept his own private gang of slaves for the maintenance of the aqueducts and delivery tanks

CARPENTERS.[1]

and basins. This gang was given to the State as its property by Augustus, who had received it in inheritance from Agrippa."

This introduces us to the labor element of the operation of the waterworks.

BLACKSMITH.[2]

STONE-CUTTERS.[3]

Of these slave bands there were two, — the one already mentioned, numbering two hundred and forty men, called those of the State; and

[1] From a painting in Herculaneum.

[2] Blacksmith using the sledge-hammer; from the Virgil of the Vatican.

[3] Stone-cutters (*lapidarius*); from the Virgil of the Vatican.

another (Chapter 116), called those of Caesar, established by Claudius (about 40 A. D.), numbering four hundred and sixty men. Many trades were represented among them, such as overseers, reservoir-keepers, line-walkers, pavers, plasterers, plumbers, masons, etc.

CARPENTER.[2]

They were managed from an office called the *Statio Aquarum*, referred to in Chapter 119, where Frontinus speaks, rather slightingly to be sure, of the "builders in the employ of the office."

The office is also immortalized by an inscription on a lead pipe of one M. Marius Festus, who tells us that he belonged to the *Statio Aquarum*, the office of the water department.[1] Archaeological studies of tombstones, lead pipes, and other records have revealed a wonderful list of employees of this office in addition to the chief engineer, superintendent, or sole water commissioner (the *curator aquarum*), such as the principal assistant, or deputy commissioner (*procurator*); several architects, by which term is meant a superintendent capable of directing any and all classes of workmen employed;[3] several clerks, or secretaries; two lictors, or special policemen; some public criers and orderlies; and two bands of slaves. These last included a foreman, a water-registrar, a lot of levellers, notebook-keepers, reservoir-keepers, pavers, line-walkers, plasterers, and other workmen. To illustrate what a learned and diligent seeker after

MASON.[4]

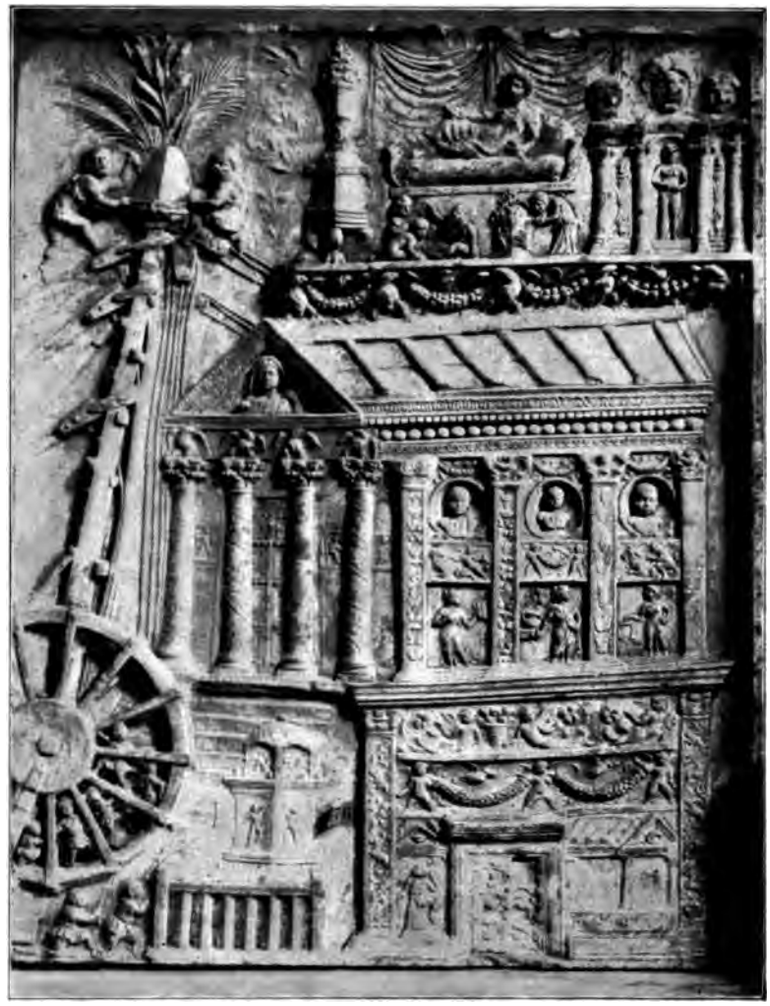
[1] Lanciani, *Frontino*, p. 530.

[2] From a Gallo-Roman tomb.

[3] In the course of time some of these became "hydraulic" architects, others military engineers, and these again separated into civil and military engineers.

[4] From Trajan's Column.

such information, working with the enthusiasm of youth, can accomplish, it may be mentioned that Lanciani gives the names and partial history of sixteen *curatores aquarum* who came after Frontinus,



ROMAN DERRICK.[1]

besides giving information about the seventeen named by Frontinus as having preceded him, and gives also the names, and other data concerning them, of forty-two deputy commissioners who lived from Tiberius to Diocletian, a period of two hundred and seventy years.

[1] Lateran Museum. Note the small boys in the tread-mill that winds up the "fall."

We touch now upon a characteristic of the times we are considering, the presence of slave labor, and, moreover, in its most debasing form, namely, that in which master and servant are of the same race.

TOMBSTONE.[1]

To the American of mature years, but who can remember what this country was like in the late 'forties or early 'fifties, to one who has seen negroes sold at auction, and who lived as a youth through the

[1] Tombstone of a Roman architect of the time of Frontinus in the Galleria Lapidaria of the Vatican. From a photograph taken for the author. Note the lock on the side of the monument, emblematic of the profession of an architect. On the other side, see p. 249, is a square.

stirring times of the abolition of slavery, from 1855 to 1865, the reading about slave life in Rome must present quite different and a far

TOMBSTONE.[1]

more complete train of thoughts than the like reading can possibly produce in the brain of a teacher of youth, be he ever so learned,

[1] Same monument as on p. 248. The inscription may be translated as follows: Gaius Vedennius, son of Gaius who was governor of Antium (was) in the sixteenth legion of the service (called) Gallica ten years, was transferred to the 9th cohort as prefect, in which in the eighth year of service he was mustered out with an honorable discharge, (but was) recalled by the emperor and made an "Evocatus Augusti"; (he was appointed) imperial architect of an arsenal(?); (was subsequently) called out for service in the 23d year (since he first served?) (and was) presented with military rewards twice by the (now) departed Vespasian and the Emperor Domitianus Augustus Germanicus.

when his life has been spent in a European university town, or immured in a study closet.[1]

Wherefore it may have happened that a just portraiture of the effect of slave life on ancient times is not readily found in books. Even so judicial and able a writer as Boissier makes the mistake of

TOOLS OF AN ARCHITECT FOUND AT POMPEII.[2]

inferring from a few surface indications that slavery was different and better in character in Rome at one time than another; whereas it is the thing itself that is uniformly vicious. There have been all sorts of people at all times everywhere, but nowhere and at no time has slavery failed to bring out the worst passions of men, nor failed to work even

[1] Boissier, *Cicéron et ses Amis*, says, p. 26: "One becomes too hard and rigid to judge of life as it is when one judges of the conduct of men only by those inflexible theories which are hatched out in solitude, and which have not been themselves tested in actual life."

As for slavery, see same, 69 and 113.

[2] These have been reproduced in bronze by a Naples firm. Note the two folding foot-rules at the bottom. Plumb-bobs on the upper shelf.

more harm to the master than it did to the slave.[1] When we read about the shiftless way in which some parts of the operation of the

ANCIENT STATUE OF A ROMAN SLAVE.[2]

waterworks of ancient Rome were carried on, we may be sure that the employment of slave labor had much to do with it. When we read

[1] Wallon, *Histoire de L'Esclavage*, 1847, a book in 3 vols., written with respect to the abolition of slavery in the French colonies, takes a similar view of his subject. According to him the original abolitionist was a monk of the ninth century, of a monastery near Constantinople.

[2] Lateran Museum in Rome.

about the amount of fraud and thievery connected with it, we may be sure that slave labor lay at the bottom of it. There is always a great temptation to draw water unlawfully, but the picture that Frontinus gives us of that sort of gross misdemeanors reveals the spirit of the slave in addition to that of the secret filcher of water.

The Emperor Zeno Augustus of the Eastern Empire (about A. D. 476) attempted to bring his slave water-men under stricter control, and this is the way he set about it. He issued the following decree, to Pontius: "All water-men or guardians of the aqueducts, known as *hydrophylaces*, in whose charge principally are the aqueducts of this royal city, shall be marked (branded) on their hand with our imperial name.

"In that way they will be recognized by all, and neither the overseers of our houses nor any one else will be able to employ them for other purposes; they are not to be used to fill drafts for laboring men nor on the public works.

"And if any one of these guardians shall die, he who replaces him shall be marked with the same sign; they will thus form a sort of military body constantly on guard for the work that is confided to them, and not to be distracted by other occupations."

117. "Of these [water-men], some must be outside the city, for purposes which do not require any great amount of work, but demand prompt attention; the men within the city at their stations at the reservoirs and fountains will devote their energies to the several works, especially in case of sudden emergencies, in order that a plentiful supply of water may be turned from several wards of the city to those which are threatened with deprivation. Both of these large gangs, which occasionally were taken, by exercise of favoritism or by negligence of their foremen, for employment on private work, I resolved to bring back to some discipline and to the service of the State, by writing down the day before what each one was to do, and by putting in the records what it had done each day."

118. The water-rights granted to gardens and buildings, adjacent to aqueducts or cisterns, or fountains, or water-basins, yielded nearly 250,000 sestertii annual income, about $10,000 worth weight of gold or $40,000 of money to-day.

120. "The necessity of repairs arises from the following reasons: By lawlessness of the owners of fields traversed, by age, by the weather, or by poor workmanship in the original construction, which has happened frequently in the case of recent work."

121. "As a rule, those parts of the aqueducts which are carried on arches, or are placed on side-hills, and of those on arches, the parts that cross rivers, suffer most from the effects of age or of the elements. Therefore must these be built with special diligence. The underground portions, not being subjected to either heat or frost, are less liable to injury. Repairs are either of the sort that can be made without stopping the flow of the water, or such as cannot be made without emptying the conduit, as for example those which have to be made in the channel itself."

122. "These latter become necessary from two causes: either by increase of deposit, which sometimes hardens into a crust, and thus diminishes the size of the channel; or by destruction of the concrete lining, causing leaks, which of course do injury to the side-walls of the channel, and to the substructure. Sometimes even the piers, which are built of "tufa," yield under their great load. Repairs to the sides of the channel should not be made in the summer time, so as not to stop the flow of water at a time when the demand for it is the greatest, but should be made in the spring or autumn, and moreover, with the greatest speed possible, in order that when all preparations for hurrying the work have been made, the flow of water may be interrupted as few days as possible. As every one can see, one aqueduct must be taken at a time, for if several were cut off at once, the supply would prove inadequate for the city's needs."

123. "Repairs that can be carried on without cutting off the water of the aqueducts consist principally of masonry work, which should be executed at the right time, and conscientiously. The proper time for masonry work is from the first of April to the first of November; but with this restriction: that the work be interrupted during the hottest part of the summer; because moderate weather is necessary for the masonry properly to absorb the mortar, and to solidify into one compact mass;[1] for the heat of the sun is no less

[1] Vitruvius, ii. 3, 2.

destructive to masonry than is too violent frost. Nor is greater care required upon any works than upon such as are to withstand the action of water; for this reason all parts of the work need to be done exactly according to the rules of the art, which all the workmen know, but few observe."

124. "But there are methods for meeting even these difficulties [to repair a conduit on arches without stopping the flow of water any great length of time]; a foundation is built up to the level of the defective conduit, and the channel is continued over the length of the destroyed portion by means of lead conduits."

Concerning this construction of aqueduct channels of lead, more will be said in a following chapter.

128. "But many [land-owners] have not been content to assume control up to the boundaries, but have laid hands on the aqueducts by diverting, here and there, some of the water to their own use through the side walls of the punctured channels; this having been done, not only by those who have a right to draw water, but also by those who misuse the least favor given them by attacking the walls of the conduits."

That is to say, that when they received a grant of a water-right, instead of applying to the water commissioner to designate to them the tank or cistern from which to draw, they attacked the channel of one of the aqueducts, and helped themselves *ad libitum*.

It is not unlikely that some such scheme of robbery possessed the fertile brain of M. Valerius Martialis, the poet (A. D. 40–102 or 104), who was always begging something of somebody, when he wrote his application for a grant of a water-right in verse, comprising his Epigram 18 of Book IX.: —

"To Caesar Domitian, — I own, Caesar, and may it long be under thy reign, a little villa and a modest city hearthstone. But it is by force of arms and by operating a pump-handle that we draw from a narrow well the water needed by my suffering gardens. Thus it happens that while my domicile complains of not receiving a drop of moisture, I yet hear the murmur of my neighbor Marcia's stream. Any permit that thou mayst grant to my household, Augustus, will be to it like as the waters of Castalia, or as the showers of Jupiter."

A poet who got his water free of charge could of course afford to use city water to irrigate, as well as waste water upon, "*sitientibus hortis*" (thirsty gardens). The records preserved have not as yet stated whether this application was granted. It also antedates Frontinus' term of office; but we may be sure that if Frontinus ever had power to deal with the case he applied the ancient equivalent of "restrictions on the use of the hose," or possibly introduced meter rates, so as to enlist the co-operation of our shiftless and impecunious poet in a prudent and economical use of water.

CHAPTER X

MAINTENANCE AND REPAIRS

Tempus edax rerum.
OVID (43 B. C. to 17 A. D.), *Met.* xv. 234.
Time, the devourer of all things.

A REVIEW of the ancient inscriptions and other sources of knowledge that relate to the repairs constantly made necessary on the aqueducts of Rome inevitably brings one to the conclusion that, so far from meriting unalloyed admiration, or from being taken as models at the present day as regards their fitness to convey water and their durability of construction, they may, on the contrary, be subjected to valid engineering criticism on both accounts. Frontinus recites how Appia and Anio Vetus were out of repair when Marcia was built (145 B. C.); how Agrippa (34 B. C.) built Julia, *and in the same year*[1] restored Appia, Anio Vetus, and Marcia. This must mean, however, that these aqueducts were out of repair merely, and not destroyed, or else they could not have been restored to use in one year, — a year, moreover, in which a new aqueduct was under construction. Nevertheless, only twenty-nine years later, as we read on the St. Laurentian gate, "Augustus, son of the Divine Caesar, sovereign Pontiff, in the twelfth year of his consulate, the nineteenth year of his office as tribune, fourteen times proclaimed emperor, repaired all the water channels" (*rivos aquarum omnium refecit*).[2] This was 5 B. C. But other inscriptions tell of repairs on Virgo A. D. 31, again in 43, and in 44; on Claudia and Anio Novus in 52; Claudia again in 71, after nine years of disuse, or after running only ten years; Marcia in 79; Claudia and Anio Novus again in 80, after running nine years, and Claudia again in 84; then Marcia again in 103, being about the time of Frontinus' death. It is very evident that these works suffered

[1] *De Aquis*, 9.
[2] Also on the "Monumentum Ancyranum" (Middleton, i. 386).

severely from the action of the elements, and, it may be argued, had not originally been properly designed or constructed.

The fault was with their design.

In the first place, it is all wrong to construct of masonry any continuous, simple channel above-ground, and expect it long to hold water. The mere expansion and contraction of the stone-work, beaten upon by the great heat of the sun in summer, as Frontinus tells us, and exposed to frost in the winter, will speedily crack such masonry channels, or their thin concrete lining. A crack once formed, the water will soon make it larger, for to no work is the proverb of "a stitch in time saves nine" more applicable than to works conveying or storing water.

And yet is the knowledge and full appreciation of this one of the most recent acquisitions of modern engineering, dating, as it were, but from yesterday. When the Sudbury conduit was built for Boston, Mass., about 1874, the masonry aqueducts on the line were constructed in a manner probably superior to any aqueducts that had anywhere preceded them, as regards this very point of providing for the expansion and contraction of the masonry channel by heat and cold, and of allowing it to thus change its length without affecting the main structure. This was done by making clear lines of demarcation between the bridge proper or carrying member, and the water channel. Nevertheless, twenty years' service showed unmistakably that masonry alone could never succeed in the unequal contest, and would always become leaky in the course of but a few years, when exposed to a northern climate. It may be sufficient thus to build in Southern France or in the tropics, or in Southern California; it is not sufficient where the range of temperature is 120 degrees of Fahrenheit outside, forty or forty-five degrees in the water itself.

So much being settled, the method of construction followed by the same engineers in 1898, in building the Nashua aqueduct, becomes interesting. It becomes doubly interesting to a student of Frontinus, when he observes that they made their original and permanent structure in the way that Frontinus describes in Chapter 124 as a method of making quick repairs. They lined the channel with sheet lead, for its whole length, building with brick for stability, both inside

and outside of the sheet lead, but depending on the plastic metal to keep the channel water-tight.

One of the curious things about the ruins of the Roman aqueducts is the brick substructure, consisting of several rings of brick arches with plenty of concrete stuffing between the several rings, which may be seen under the massive dimension-stone arches of Claudia and of other aqueducts. More than that: a piece of the channel of Marcia, near where the railroad cuts through it, a short distance west of Porta Furba, is entirely encased in such a subsidiary construction, besides having such brick and concrete arches built up under the arches of the main structure.

I have never seen any proper explanation of this sort of work, the subsidiary arches being generally referred to as having been built to "help support" the aqueduct, which explanation, I venture to say, is, however, not to be thought of for a moment. So far from these brick and concrete arches helping to support the masonry arches above them, there are places on Claudia where that portion of the former which is next the ground has been knocked out from under the remainder, and has left the brick arches themselves and their brick abutments hanging by adhesion to the stone-arches above them.

The conclusion that I have come to about these described parts of structures is that they were built to stop leaks, both the brick arches, and the outside envelope of Marcia's channel above referred to. The Romans could not very well work from the inside of the water channels for two reasons: they could not spare the use of these channels during the time it would have been necessary to draw the water from them during such repairs; and the interior was subject to great diminution of cross-section as it was, by reason of incrustation from the hard water, so that they could not spare the room that such interior patching and plastering would have taken away from the useful cross-section of the channels. So they decided to work from the outside. But in so doing they tried to accomplish their purpose by what the modern plumber calls "working against the pressure," and as every one in the trade well knows, and as any one can see on the ruins of the aqueducts, they had a most uncomfortable time of it. A correct analysis of what may be seen on the ruins also explains, in my opinion,

to the fullest extent, why there are so many inscriptions that detail the repairs of the aqueducts. The truth is, that these much vaunted works, whose *ruins* stand so long, were very poorly designed to *contain water*. The amount of leakage from them, as has already been said, must have been something enormous at all times, until in a very few years, as we have seen, one or the other, or three at a time, would be

CLAUDIA, WITH ANIO NOVUS ABOVE IT.[1]

found to have grown so leaky that some enterprising emperor would distinguish himself by restoring them for a short period to usefulness. Sad as it may seem to be obliged to acknowledge it, the Romans apparently did not fully appreciate what an up-hill job it is to "work against the pressure." Or else they had not ingenuity enough by skilful design of the aqueducts to disenthrall themselves from the necessity of being obliged to do so, did they wish to keep the aqueducts staunch and in condition to deliver water.

[1] Note the brick arch under the masonry arch near the centre of the figure, suspended by adhesion from this masonry arch. Another such case was shown on p. 176.

The cupidity and thoughtless selfishness of the public contributed in no small degree, as we have seen, to the diversion of the waters of the aqueducts before they reached the city. To cap the climax, the right to take and conduct water leaking from the aqueducts, or overflowing from fountains, or otherwise wasting, was made the subject of a grant. It requires but little imagination to see how such grants were not suffered to lapse, by the grantee, for want of water wasting or leaking, if he could help it; and he, no doubt, generally could. Leaks probably grew larger, instead of being promptly repaired; and overflow and waste could be readily increased by the assistance, or only passive demeanor, of a properly persuaded water-man.

We may remember, in this connection, that description of Fabretti's of the lime deposits, from leaks that formed in places on the outside of the aqueducts, wherein he likens them to hay-stacks; and to my own observation under the arches of Claudia of a net-work of incrustations like great creepers, most of them as large in diameter as a man's arm. Leaks of this sort evidently ran both a long time and in abundant quantity. Considerations such as these readily explain to us how these frequent overhaulings and repairs of the aqueducts were made necessary; and how in spite of them, as we have seen, Rome seldom, if ever, received the water of all her nine aqueducts at the same time.

To continue the history of these nine aqueducts, we find Septimius Severus repairing Marcia and extending it to his Thermae, in A. D. 196; and Caracalla repairing them all in 212. Claudia is running in 399, and in 402, as shown by two laws then passed with regard to it. In the year 500, Theodoric writes to Cassiodorus about Virgo, as already quoted. In 536, Procopius, coming to Rome with Belisarius, finds eleven aqueducts there, though he says he found fourteen.

In 537 Rome is besieged by the Goths and Burgundians, who destroy the aqueducts. They made a fort, or walled camp, of one portion of them; a tower, Torre Fiscale, thus built by them, at the intersection of several of the aqueducts, standing to this day. Nevertheless, Belisarius restored Claudia and Trajana between 537 and 549. Somewhere between 548 and 568 the aqueducts all ceased to convey water, and so remained until about 776, or over two hundred years,

when the Popes, put in power by Charlemagne, commenced to repair them.

In 776 Adrian I. restored Trajana, Marcia, Claudia, and Virgo, in the order named.

We find Claudia in use in 795, under Leo III., Adrian's successor. From 1120 to 1122, Calixtus II. used Claudia, and that is the last we hear of Claudia as a running stream of water, after its fitful existence of 1070 years.

Virgo was restored by Nicholas V. in 1447, and remained in use thirty years. Seven years after, 1484, Sixtus IV. restored Virgo. 1550 to 1555 Julius III. used its leakage waters, and in 1559 it had ceased to flow. That year Pius IV. repaired Virgo, which repairs sufficed for eleven years. Then in 1570 Pius V. restored Virgo; since when Gregory XIII., Clement XII., in 1735, and Benedictus XIV. in 1744, made changes, extensions, and improvements; and the spring "Virgo" is conveyed to Rome to-day. It now yields some sixteen million gallons per twenty-four hours.

CHAPTER XI

THE LAW OF WATER-RIGHTS IN ROME, A. D. 97

Roma aeterna.
TIBULLUS (54–19 B. C.), ii. 5, 23.
Eternal Rome.

ANOTHER instructive feature of the Two Books of Frontinus is found in the paragraphs in which he deals with the law of water-rights, a subject that now, as well as then, no conscientious supervisor or administrator of water-power, or of water-conducting properties, can afford to ignore or neglect. It is significant to observe, in this connection, that in Bruns' "Fontes," a work giving the sources of the Roman law, the subject of water-rights is treated principally by means of extracts from Frontinus. I commence with Chapter 94. "No private person shall conduct other water than that which flows from the basins onto the ground." This is ancient law, says Frontinus. And even this much was granted only to public baths and to fulling-mills. In another place, 110, Frontinus adds: "Those waters also that I have called lapsed, namely, those that come from leakage out of the cisterns or the pipes, are subject to grants; but these are only rarely given by the sovereign."

107. "The right to granted water does not pass either to the heirs, or to the buyer, or to any new occupant of the land. The public bathing establishments had from old times the privilege that water once granted to them should remain theirs forever. We know this from old votes of the Senate, of which I give one below. Nowadays, every grant of water is renewed to the new owner." And then follows the law, 108, which I will not transcribe.

109. Thirty days' notice was given by the Emperor Nerva, before the water was to be shut off. In case of syndicates, the grant held till the last member of the syndicate alienated his interest in the estate.

Similar regulations with regard to overflow water are found in the laws (43 B. C.) of the colony of Genetiva,[1] a Spanish colony, now called Osuna, Sec. 100: "If any colonist shall wish to conduct waste water for private uses, he shall go to the duumvir and shall demand that the matter be referred to the decurions. Then that duumvir to whom

ROMA AETERNA.[2]

application has been made shall refer the matter to the decurions when not less than forty are present. If the majority of the board who are then present shall rule that the waste water can be used for private purposes, let this water be used to such an extent as may not do injury to any private person, and let there be right and power so to do."

[1] Bruns, *Fontes Juris Romani Antiqui*, sixth ed., p. 133.

[2] The celebrated supposedly Etruscan statue of a she-wolf and the twins, typifying the founding of Rome. From the Capitoline Museum. "So ugly that it is handsome."

PUBLIC BATHING ROOM IN POMPEII.

A brazier to heat the room behind the grating.

Frontinus speaks of baths and the fulling-mills as favored consumers of water in Rome under the law, as indeed they long were. If I do not describe the use of water by the baths of Rome to any great extent, it is because that subject is the common property of so great a number of books; beginning with the monologue, "De Thermis veterum," of good Dr. Andrea Baccio, professor of botany in

ANCIENT ROMAN UTENSILS FOR THE BATH.[1]

Rome 1567–1600 and thence extending through almost every treatise on Roman architecture, or on the remains of ancient Rome, down to the present day. I give only a few illustrations of such baths selected from many procured in Rome and Naples.

The following passage may serve to show the luxury indulged in by the Romans in this matter of elegant bathing establishments, in the

[1] The curved pieces are used to scrape the limbs and body; the others are vessels to hold unguents, and metallic looking-glasses. From Pompeii.

first half of the first century. Seneca,[1] having gone on a visit to the villa, then some two hundred years old, of Scipio the greater, at Liternum, in Campania, was astonished to find how simple, plain, bare, and dark the bathing rooms were. "Who would be content with such at the present day?" says he. "Who would not consider himself a beggar if he bathed in a room whose walls did not shine with the fire

SCENE OF BATHS (WOMEN).[2]

of jewels; if the marble of Egypt were not inlaid with the marble of Numidia and panelled with mosaics; if the ceiling were not wainscoted with crystal; if the tanks were not carved out of Parian marble; if the water did not flow from silver faucets? And yet I am speaking only of the baths of the people: what shall we see when we come to those of the select? What statues! columns, which have nothing to support, and which are there only for ornament! What masses of water falling in cascades with a loud noise! We have reached such a refinement of luxury that our feet may not tread upon anything but precious stones."

[1] Seneca, *Epist.*, 86, 1, 6.

[2] From a vase in the Hamilton Collection (Tischbein, vol. i. pl. 59).

Not so well-known is the standing of the cloth-fullers in Roman life. At a time when the Romans called themselves "the masters of the world and the toga-wearing people," when the toga was the distinguishing mark of every self-respecting citizen, young and old, it naturally became important that these light-colored or white woollen mantles should be often cleansed. To some extent, the Roman fuller took the place of the modern laundryman; at all events he was a much more important member of the community, and much more nu-

SCENE OF BATHS (MEN).[1]

merously represented in it, than the modern fuller. One of the finest blocks in Pompeii belonged to the guild or *collegium* of fullers, and the remains of several fulling establishments may there be studied instructively, so completely are the essentials of the shop preserved. To complete the lesson, there are in the Museum at Naples some wall paintings from a *fullonica* of Pompeii, that represent a shop of fullers at work.

In Rome, on the Esquiline Hill, were found, at intervals of more than one hundred and fifty years, the pieces of an inscription, detailing the progress and final decision by three successive chiefs of police

[1] Tischbein, vol. i. pl. 58.

and of the fire department of Rome, (A. D. 226 to 244, eighteen years), of an arbitration in which a certain guild of fullers claimed exemption

ANCIENT POLISHED STONE CHAIR USED IN THE BATHS.[1]

from water-rates by reason of ancient grants of water, and some religious considerations in the grant.[2] It is not clear who it was that claimed that the fullers should pay, but following Bremer, in Rhein.

[1] From the Vatican. There is a fine specimen in the library of Montecassino, found in the valley below.

[2] See p. 77, Ossig, *Römisches Wasserrecht*, 1898.

Museum, 1866, 10, this would seem to have been certain contractors for the collection of water-rates (perhaps those due from the use of spring water, as distinguished from aqueduct water), and other taxes. The fullers finally carried the day.[1]

Although water-right holders were mere life-lessees, it is reasonable to assume that the rule was, that successors could get a renewal of a

A BABY'S SITZ BATH-TUB.[2]

water-right grant. Frontinus speaks of a renewal in Chapter 109, and without a fair prospect of a renewal few could have afforded to put in the lead pipes we have been considering, and other fixtures.

I go on with a review of the legal chapters of Frontinus' "De Aquis."

97. "But lands, of which it could be proven that they had been irrigated unlawfully from the public supply were confiscated. A tenant, one of whose slaves infringed the law, even without the

[1] This is the so-called *lis fullonum;* for which see Bruns, *Fontes, Negotia, Causae forenses;* C. I. L., vi. 266; Lanciani, *Ancient Rome*, 223; *Zeitschrift f. gesch. Rechtsw.*, xv. 248.

[2] From a photograph, taken in the Magazzino Archeologico at Rome, by the author.

knowledge of his master, was punished by a fine." Another law reads thus: "No one shall with malice pollute the waters where they issue publicly; should any one pollute them his fine shall be 10,000 sestertii." (Equal then to about $450 coin, or say $1100 to-day.)

103. "No one shall draw water without a writing from Caesar, that is, no one shall draw water from the public supply without a

ADVERTISEMENT OR STREET SIGN OF A BATH.[1]

license, and no one shall draw more than has been granted." "By this means we propose to make it possible," says Frontinus, "that the quantity of water, concerning whose recovery we have spoken, may be distributed to new fountains, and may be used for new grants from the sovereign. But in both cases must a great zeal in the service be

[1] From near the Via Nomentana, not far from the eighth milestone. Set up, presumably, at the lane which led to the bath. No. 6 in the Galleria Lapideria of the Vatican. From a photograph taken for the author. *In his praediis Aureliae Faustinianae balineus lavatri more urbico et omnis humanitas praestatur.* "On this estate of Aurelia Faustiniana is a bath according to city style, and everything that may be required is offered." A similar tablet was found near Bologna, described by Marini, *Atti dei Fratelli Arvali*, 532.

opposed to manifold forms of fraud. The channels of the aqueducts without the city must be frequently examined, one after the other, to review the granted quantities; the same must be done in case of the delivery tanks and fountains, that the water may flow without interruption day and night; which the commissioner has been directed to see to by vote of the Senate, whose words are as follows:"

There follows a long vote of the Senate, 104, thus specifying. Another rule, 105: "Whoever wishes to draw water for private use must

FULLER'S ESTABLISHMENT AT POMPEII.

seek for a grant and bring to the commissioner a writing from the sovereign."

106 is the law prescribing fifty feet of pipe next the ajutages, already spoken of; also prescribing the draft to take place from the delivery tanks, so that the public water-channels be not tapped too often.

I have mentioned the laws of the colony of Genetiva, given in Bruns' "Fontes." Another old law on aqueducts found in this collection

and antedating Frontinus by about one hundred years, is the decree of Augustus governing the aqueduct of Venafrum, an old Samnite

A WALL PAINTING FOUND IN A FULLER'S SHOP AT POMPEII. [1]

city. This decree does not apparently prescribe tapping the delivery tanks, nor prohibit tapping the aqueducts, though it prescribes the

[1] Number 9,774 of the Naples Museum. Much faded, but by careful inspection may be seen, above: a woman seated, and a little girl; two male figures, being fullers at work; the

fifty feet length of pipe next the tap, as in Rome.[1] Laws of the third and fourth centuries become more lax, and finally permit in terms the tapping of the aqueducts by grantees;[2] as might be expected in a time of national decadence.

"That granted water cannot be carried elsewhere than upon the premises to which it has been made appurtenant," says Frontinus, "or taken from another delivery tank than the one designated in the writing of the sovereign, is self-evident, but is also forbidden by ordinance."

111. "I desire that no one shall draw lapsed water except those who have had permission to do so by grants from me or preceding sovereigns; for there must necessarily be some overflow from the delivery tanks, this being proper not only for the health of our city, but also for use in the flushing of the sewers." And previously, in Chapter 88 Frontinus has told us how by obeying this law or ordinance he had improved the air of the city and redeemed the same from the bad name it erst had "with the ancients."

125 treats of the subject of taking by right of eminent domain materials from adjoining estates, for the purpose of making repairs, and the taking of rights of way to the aqueducts, for the same purpose. They are appraised by an arbitrator, and paid for.

127 gives the full extent of the law of 11 B. C., forbidding, under penalty of a fine, the planting of trees or otherwise occupying a strip, fifteen feet wide, each side of the aqueducts.

128 touches upon the right of eminent domain for the taking of lands. In constructing the works, the predecessors of Frontinus had often taken the whole of a man's estate, whenever the owner so preferred, had then used what was necessary, and sold the balance.

Livy speaks of the difficulty experienced by the censors M. Aemilius Lepidus and M. Fulvius, about 179 B. C., when they were "appointed a commission to locate an aqueduct. An obstruction to the work, however, was M. Licinius Crassus, who would not allow the aqueduct

cage-like structure is either a bird-cage for the owl (sacred to Minerva, the special patroness of the guild of fullers), which is shown perched on top of it, or it is a frame on which to dry cloth. In the lower painting the figures are engaged in washing cloth; some with their hands, some by treading the cloth with their feet.

[1] Line forty-four of the Decree.

[2] Lanciani, *Frontino*, 596.

to cross his property."[1] Of course that sort of dog-in-the-manger exercise of rights could not continue in a growing commonwealth, and we find both the laws already cited, Lex Genetiva of 43 B. C., and the Augustan decree referring to the Venafrum aqueduct, providing for the lawful acquisition of rights of way. Private parties had not the right to carry water through the lands of others in Venafrum in the days of Augustus, though they have had it in common with all the rest of Italy for many centuries since then. This special right of eminent domain called the "right of passage" in Italian and other water codes of Continental Europe, thus given to any person, provided the object of the hydraulic work to be undertaken be of public benefit and contributory to the welfare of the State, forms the very foundation of the irrigation practice of all Italy. Without it the land could not support the population that now inhabits that country.

The Constitution of the State of New York, by revision of Article I., Section 7, in 1894, permits the legislature to pass laws giving such a right of eminent domain to any person when the hydraulic work to be undertaken is for *agricultural* purposes; and it may well be that in course of time this somewhat demagogical limitation will be removed, so that mining, milling, domestic, or sanitary supplies of water may also be encouraged, and may multiply and thus promote the public welfare.

I have ventured to reprint the argument, provoked by a study of water-law in general, which led to the change in the Constitution of the State of New York just referred to, in an Appendix to this chapter, as being of more than passing interest in most of the States of the Union.

It goes without saying that proper compensation was made to the original owner, in all the cases mentioned, and, indeed, from the time of the Roman kings.

Paulus, third century, says: "If any aqueduct running through lands damages private property, it will be a duty, according to the Laws of the XII. Tables, to protect the private owner from harm," which is going back as far as it is practically necessary or useful to go.

[1] Livy, xl. 51.

Chapter 129 of Frontinus contains the germ of the present article of the Codes of Italy and other European countries, which exempts a man's domicile and certain lands about it from the above-named "right of passage," for works contributing to the public welfare.

An interesting legal exhibit, relating to Frontinus' time, has already been spoken of as lost to us. When it is considered what limited interest for one thousand years the transcribers in the monasteries presumably had in temporal subjects, the wonder is not that so much has been lost, but rather, that so much was nevertheless preserved. It is well to remember that our knowledge of ancient times is not entirely such as the ancients themselves pictured themselves, but only such as has been retained on the filter of transcribed manuscripts. According as transcribers took an interest in ennobling, or in trivial or even in debasing subjects, they copied and circulated the one or the other class of literature; and but few or none of them would probably be interested in the speech of Caelius Rufus, "Concerning Waters."

Says Frontinus: 76. "Concerning misdemeanors of this sort [unlawfully taking water] nothing more nor better needs to be said than was said by Caelius Rufus in his speech, which is entitled 'Concerning Waters.' And would that we were not having daily experience by actual infringement of the law that all these misdemeanors are committed just as flagrantly now as then. Irrigated fields, shops, garrets even; lastly, disorderly houses have we found fitted up with constantly flowing fixtures. For that some waters should be delivered under a forged name in place of other waters belongs to the *lesser* misdemeanors."

When he says this, as when he utters many another sentiment of his little treatise, Frontinus awakens the sympathies of every one who has ever had the administration of water-supply or water-power properties in his charge. Times change, but in certain respects and contrary to the verse of the poet, we do *not* change with them. Some of the attributes of human kind bear a strangely familiar look throughout all the ages.

CHAPTER XII

THE CHARACTER OF THE WATER COMMISSIONER, SEXTUS JULIUS FRONTINUS

His ego rebus pascor, his delector, his perfruor.
CICERO (106–43 B. C.), *In Pison.*, 20.
With those things am I feasted, these I delight in, these I thoroughly enjoy.

WE have thus reached the end of our consideration of life in ancient Rome from the point of view of a waterworks superintendent of the time, and as commented on by a hydraulic engineer and superintendent of water-properties of the present day. It must have afforded but another illustration that life in ancient Rome is a very different thing according to the point of view and according to him who describes it. If any one, for instance, will take Gaston Boissier by the hand and will allow oneself to be led by him on one of that author's charming "Promenades" through Rome or its environs, or through some of its other towns or colonies; or will allow Mrs. Frances Elliott to pass before his eyes as he reclines in his easy-chair some of her delightful word-pictures of life in Rome, he will get a very different notion of what ancient Rome really was from what he must if he only stood up to be drilled in Roman History, so-called, or to be shouted and scolded at by some other writers I might name about the sins and shortcomings, and nothing else, of almost every man, woman, and child who figures in that "frightful machine," — as Montaigne calls "The History of Rome."

In Frontinus we have had a guide whose distinguishing characteristics, as revealed in his treatise "De aquis urbis Romae," have had their effect in the picture he has presented to us. It may be proper now to review them and thus still better learn to know the water commissioner of A. D. 97 from these "II. Books" he has left us.

Nothing could exceed the zeal, the love, he shows for this his work, undertaken at the age of about sixty-two. And a selection of his own words is the best proof of this.

1. "Inasmuch as every office conferred by the emperor demands especial attention; and inasmuch as I am moved not only to devote diligence, but even love to any matter confided to my care, be it on account of inborn zeal, or by reason of faithfulness in office; and inasmuch as Nerva Augustus, an emperor of whom it is difficult to say whether he devotes more love or more diligence to the common weal, has now imposed upon me the duties of water commissioner [*curator aquarum*], duties contributing partly to the uses, partly to the health, even to the safety of the city, and from olden time exercised by the most distinguished citizens; I therefore consider it to be the first and most important thing to be done, as has always been one of my fundamental principles in other affairs, to learn thoroughly what it is that I have undertaken.

2. "There is, indeed, no better foundation for any business; nor can it in any other way be determined what is to be done, and what omitted; nor is there for a fair-minded man so debasing a course as to fulfil the duties of an office entrusted to him according to the directions of assistants: a course, however, which must be followed, whenever an inexperienced official takes refuge in the practical knowledge of his assistants; whose services, although necessary for rendering help should nevertheless be only a sort of hand and tool of the principal in charge. It is for this reason that I have set down in this commentary all that I could gather as bearing on the subject matter, after having arranged and codified it in accordance with my habit as already exemplified in other offices, so that I might consult it as a guide in the duties of this. But my other commentaries were inspired by my own hard-earned practice and experience, and were intended for the benefit of my successors, and this commentary may also be of use to a successor; but as it has been written at the beginning of my administration, it will serve more especially for my own instruction, and as a guide."

17. "It has seemed to me not superfluous to examine consecutively the lengths of channel of each aqueduct in its several parts, and in detail; — this because the maintenance of the works is the most important part of the duties of this office, wherefore it is necessary that whoever is placed in charge of them should know which of them

are in need of having money spent upon them. But my zeal was n satisfied by a mere personal examination in detail; I also had pla made of the aqueducts, from which it may be seen where there a valleys, and how wide they are, and where rivers have been crosse also where the conduits laid on the hillsides need an extended a continued care for their protection and maintenance. In this way v reap the advantage of having, as it were, the works referred to direct before us, and of being able to study them as though we stood l their side."

23. "Having now given the builders and age of each aqueduc also their sources, lengths of channel, and order of heights, it seen to me not out of keeping to go more into detail, and to demonstra how large is the quantity of water which is allotted to public and private uses, as well as for luxury; and through how many tanl it is conveyed, and in what wards these are located; how much wat is distributed within the city walls, how much without, how much used for water-basins, how much for fountains, how much for publ structures, how much on account of the State, how much by priva consumers."

As we have seen, he goes on fighting waste, fraud, and unlawf taking of water, in every form, from this point on.

64. "There were, be it noted, in the aggregate, 12,755 *quinari* recorded, 14,018 discharging water; that is, 1,263 more were reporte as delivering water than had been received. Astonished at this, I fe it to be no small part of my duty to investigate, so as to arrive reliable data concerning the aqueducts and their discharge, and to s how it could come about that more was being delivered than b longed, so to speak, to the estate. So before doing anything else, set about to measure the intake of the conduits, etc."

A law having been passed, requiring lictors to accompany tl water commissioner on his journeys outside the city walls, sa Frontinus: 101. "In my examination of the aqueducts, my sel reliance and the authority given me by the sovereign will stand place of the lictors."

103. "I will now set down what the water commissioner mu observe, being the laws and Senate enactments which serve for h

guidance. As concerns the draft of water by private consumers, there is to be noted: 'That no one shall draw water without a writing from Caesar; that is, that no one shall draw water from the public supply without a license, and no one shall draw more than has been granted. By this means we propose to make it possible, that the quantity of water concerning whose recovery we have spoken, may be distributed to new fountains and may be used for new grants from the sovereign. But in both cases must a great zeal in the service be opposed to manifold forms of fraud. The channels of the aqueducts, without the city, must be frequently examined, one after the other, to review the granted quantities; the same must be done in case of the delivery tanks and fountains, that the water may flow without interruption, day and night, which the commissioner has been directed to see to, by vote of the Senate, etc.

119. "These numerous and extensive works have a natural tendency to fall into decay, and they must be attended to, before they call for large appropriations. As a rule, however, they are only to be taken hold of after due consideration; because, those who urge the construction or extension of works cannot always be trusted. The water commissioner, therefore, ought not only to be provided with advisers, but ought also to be armed with self-acquired practical experience of his own. He must consult, not only the builders in the employ of the office, but must seek aid from the trustworthy and thorough knowledge of outsiders, in order to judge what must be taken in hand forthwith, and what postponed; again, what is to be carried on by public contractors, and what done by his own regular workmen."

Referring to a law passed 39 B. C. (the Lex Quinctia), which made the damaging of aqueducts a misdemeanor, punishable by a fine of 100,000 *sestertii*, say $4,000 or $14,000 according as the intrinsic or purchasing value of money be considered. Frontinus, 130, says: "I should call the transgressor of so beneficent a law not unworthy of the threatened punishment. But those who have lived in an atmosphere of delusion, and to whom a violation of the law had become second nature in the course of time, had to be brought back to the right way of thinking by gentle means. I therefore endeavored with

diligence that as far as possible the erring ones should remain unknown. Those who sought the emperor's pardon, after due warning received, may thank me for the pardon granted. But for the future, I would wish that it might not be necessary to invoke the law, for it will be necessary to maintain the honor of my office, even at the risk of giving offence."

With this sterling resolution to do his duty should the necessity arise, we can leave our consideration of this honest old Roman water commissioner, — of the man and of his work; only adding his remark to Pliny,[1] which in his case has been realized in the fullest sense of the words uttered, and with all the import that attaches to them: —

Memoria nostra durabit, si vita meruimus.

Remembrance will endure, if the life shall have merited it.

[1] PLINY, *Epist.*, ix. 19.

Valeas, viator, lector mei carminis.

C. I. L., viii. 5370.

Fare you well, traveller, reader of my roundelay.

APPENDIX TO CHAPTER XI

APPENDIX TO CHAPTER XI

Delegate Elect to the Constitutional Convention.

DEAR SIR: This is an appeal to you, and through you to the Convention, to amend the Constitution of the State of New York to the end that opportunity may be given for the more perfect development of the natural resources of the State by means of works that serve to control water.

The thoughts and arguments herein set forth are the outcome of fully thirty years of active professional life as a hydraulic engineer in the New England and many other States of the Union; also, of experience in public office, and of a special study of the subject matter. If it be true, as says the proverb, that every one can tell where his own shoe pinches him, hydraulic engineers can very well point out the defects of the law, or of constitutions, in so far as they make impracticable, even impossible, the general development of property within the State by a proper use of water and of water-courses. Civil Engineering has been defined as "the art of directing the great sources of power in Nature for the use and convenience of man;" and the practice of the profession gives ample opportunity and incentive to observe and to analyze any man-made obstacles that lie in the way of the construction and operation of that great and beneficent class of works. Such obstacles now exist in the constitutions of this and others of the older States of the Union, but do not obtain in still older civilized countries, as will hereafter be shown. Nor do they obtain in eight of the States, who have already embodied, in their constitutions, amendments or original articles, of the general tenor herein advocated, being articles which empower the Legislature to apply a taking by right of eminent domain, and upon payment of just compensation, for necessary purposes of retaining, excluding, or conveying water.

CONSTITUTIONAL PRECEDENTS.

These constitutional precedents are as follows: —

Missouri. — Constitution of 1875, Art. II., Sec. 20. "That no private property can be taken for private use, with or without compensation, unless by the consent of the owner, except for private ways of necessity, and except for drains and ditches across the lands of others for agricultural and sanitary purposes, in such manner as may be prescribed by law."

Colorado. — Constitution of 1876, Art. II., Sec. 14. "That private property shall not be taken for private use unless by consent of the owner, except for private ways of necessity, and except for reservoirs, drains, flumes or ditches, on or across the lands of others, for agricultural, mining, milling, domestic or sanitary purposes."

Illinois. — Amendment to the Constitution, adopted by popular vote in 1878, now Art. IV., Sec. 31. "The General Assembly may pass laws permitting the owners of lands to construct drains, ditches and levees, for agricultural, sanitary or mining purposes, across the lands of others, and provide for the organization of drainage districts, and vest the corporate authorities thereof with power to construct and maintain levees, drains and ditches, and to keep in repair all drains, ditches and levees heretofore constructed under the laws of this State, by special assessments upon the property benefited thereby."

California. — Constitution of 1879, Art. XIV., Sec. 1. "The use of all water now appropriated, or that may hereafter be appropriated, for sale, rental or distribution, is hereby declared to be a public use, and subject to the regulation and control of the State, in the manner to be prescribed by law."

Idaho. — Constitution of 1889, Art. I., Sec. 14. "The necessary use of lands for the construction of reservoirs, or storage basins, for the purposes of irrigation, or for rights of way for the construction of canals, ditches, flumes or pipes, to convey water to the place of use, for any useful, beneficent or necessary purpose, or for drainage, or for the drainage of mines, or the working thereof, by means of roads, railroads, tramways, cuts, tunnels, shafts, hoisting works, dumps or other necessary means to their complete development, or any other use necessary to the complete development of the material resources of the State, or the preservation of the health of its inhabitants, is hereby declared to be a public use, and subject to the regulations and control of the State. Private property may be taken for a public use, but not until a just compensation, to be ascertained in a manner prescribed by law, shall be paid therefor."

Montana. — Constitution of 1889, Art. III., Secs. 14 and 15. "Sec. 14. Private property shall not be taken or damaged for public use without just compensation having been first made to, or paid into court for the owner."

"Sec. 15. The use of all water now appropriated, or that may hereafter be appropriated for sale, rental, distribution or other beneficent use, and the right

of way over the land of others, for all ditches, drains, flumes, canals and aqueducts, necessarily used in connection therewith, as well as the sites for reservoirs necessary for collecting and storing the same, shall be held to be a public use. Private roads may be opened in the manner to be prescribed by law, but in every case the necessity of the road, and the amount of all damage to be sustained by the opening thereof, shall be first determined by a jury, and such amount, together with the expenses of the proceeding, shall be paid by the person to be benefited."

Washington. — Constitution of 1889, Art. I., Sec. 16. "Private property shall not be taken for private use, except for private ways of necessity, and for drains, flumes or ditches on or across the lands of others for agricultural, domestic or sanitary purposes. No private property shall be taken or damaged for public or private use without just compensation having been first made, or paid into court for the owner, and no right of way shall be appropriated to the use of any corporation other than municipal until full compensation therefor be first made in money, or ascertained and paid into court for the owner, irrespective of any benefit from any improvement proposed by such corporation, which compensation shall be ascertained by a jury, unless a jury be waived, as in other civil cases in courts of record, in the manner prescribed by law."

Wyoming. — Constitution of 1890, Art. I., Secs. 32 and 33. "Sec. 32: Private property shall not be taken for private use unless by consent of the owner, except for private ways of necessity, and for reservoirs, drains, flumes or ditches on or across the lands of others for agricultural, mining, milling, domestic or sanitary purposes, nor in any case without due compensation.

"Sec. 33: Private property shall not be taken or damaged for public or private use without just compensation."

Somewhat similar provisions of the constitutions of many of the other States, New York among the number, authorize legislation for the laying out of private roads.

STATUTE PRECEDENTS.

Many of the States have gone to the point of endeavoring to legislate in manner as though a constitutional privilege, such as above written and hereafter to be outlined, already existed; and such legislation has in some of them never been called in question.

Thus, in Virginia, by enactment of 1887, the owner on one side of a water-course can in certain contingencies condemn an acre of land on the opposite bank to enable a mill-dam to be built.

In Alabama, the Civil Code of 1887 gives the same facilities for building a dam, together with others, enabling a canal not over 100 feet wide to be built, in the manner prescribed by law, over the lands of others.

There are similar laws in Delaware, Florida, Kentucky, Mississippi, Arkansas, Indiana, Iowa, West Virginia, and in the States of Missouri and Illinois, extracts from the constitutions of which have above been cited.

In other States, similar laws have been declared unconstitutional; that is to say, as will herein be argued, the constitutions of these States should be amended for the promotion of the general welfare.

NECESSITY OF ADDITIONAL LEGISLATION, PRECEDED BY AN ENABLING AMENDMENT TO THE CONSTITUTION.

As is well known, the law on the whole subject of the mill, and the flowage acts, on irrigation and on drainage, is now in a very unsettled state, and an amendment to the constitution, enabling proper legislation to be enacted, is needed for the development by hydraulic works of the natural resources of the land and of its appurtenances.

Time was, when a body of enterprising men could go off in the woods, or to some out-of-the-way place, secretly buy the necessary contiguous tracts of land, and start a manufacturing village, or even cities like Lawrence and Holyoke, in Massachusetts; like Manchester and Nashua, in New Hampshire; like Rumford Falls and Lewiston, in Maine; and like Cohoes and Little Falls in New York; all of which were practically created solely in the manner spoken of. But that day has gone by. Land is held now in too small parcels to permit of such purchases, and consequently, in default of being able to buy, or otherwise acquire the necessary land, such enterprises cannot, as a rule, now be undertaken at all, to the manifest detriment of the Commonwealth.

It is true that it has been said that it is no more justifiable to take property for mills, on the ground that their business is beneficent to the public, than to take it for groceries or for hotels. But the *capacity to have* groceries, or hotels, in many communities, would have to be dependent on the exercise of the power of condemnation to make the cases parallel. Without laws of the kind here argued for, the manufacturing cities that have been named would not now be. Such laws were originally enacted that grist and saw mills might exist, but their benign influence has made possible the beginnings of the whole manufacturing industry of the United States. These laws have nurtured it in its infancy, and important branches of it, such, for example, as the whole paper industry, are yet dependent on the product of these laws, on water-power, for their present profitable operation. It is not true that steam-power ever has replaced, or ever can replace, water-power. The latter always was, and yet is, the cheapest, and we are constantly approaching the time when it will be not only the cheapest, but the only great power now known, that will be left to us. Coal-beds and natural gas supplies are of measurable capacity, and are not replenished by nature. But the circle of motion of water from the ocean to the mountain tops, and thence to the sea again, goes on forever. At no time have capable water-

powers been of more value, immediate or prospective, than since the invention of the transmission of power by electricity, which in large measure has relieved them of the disadvantage of being immovable and attached to the soil, as compared with steam; and at no time have they been more properly a subject for the fostering care of the State.

Similar remarks could be made as to works of irrigation and of drainage; or, in the language of constitutions and of statutes, as to hydraulic works for agricultural, mining, milling, domestic, or sanitary purposes. It becomes, from year to year, more and more difficult to carry out enterprises of this sort as population increases, and as land becomes divided into smaller parcels. But waste and wet lands need to be improved; the productive capacity of all lands needs to be developed to its utmost extent. It would certainly be a public calamity if constitutional prohibitions should continually operate against all efforts in this direction. Says one law-writer: "It is the merit of modern writers on political economy to have furnished the demonstration of the principle that the proper application of the right of eminent domain is not limited by ill-defined considerations of the 'general good,' or of 'public benefit,' or of the 'public interests,' but only by the consideration that a partial change in the holding of property, especially of real estate (inclusive of water-rights), as it exists under the law, is an unavoidable and necessary condition of social development, in certain cases."

And another says: "The 'public welfare,' or the 'general good,' is not especially affected by carrying water over the land of another in single instances, no more than the health of the individual is affected by his partaking, at a certain time, or of a defined quantity, of this or that particular edible; but effective legislation to the end that artificial water-courses may, by right of eminent domain, be carried through the lands of another, is as much a promotion of the public welfare and of the general good as it is a law of nature that to live a man must have food."

PROPOSED CONSTITUTIONAL AMENDMENT.

In view of all the foregoing, an amendment of Art. I., Sec. 7, of the Constitution of the State of New York, in form somewhat as follows, is therefore respectfully submitted to the Constitutional Convention.

To insert a new sentence after the first sentence of Section 7, so that the new Section 7 shall read as follows:

"COMPENSATION FOR PROPERTY TAKEN.

"When private property shall be taken for any public use, the compensation to be made therefor, when such compensation is not made by the State, shall be ascertained by a jury, or by not less than three commissioners appointed by a court of record, as shall be prescribed by law. *The necessary use of lands for*

the construction and operation of works serving to retain, exclude or convey water for agricultural, mining, milling, domestic or sanitary purposes is hereby declared to be a public use. Private roads may be opened in a manner to be prescribed by law; but in every case the necessity of the road, and the amount of all damage to be sustained by the opening thereof, shall be first determined by a jury of freeholders, and such amount, together with the expenses of the proceedings, shall be paid by the person to be benefited."

PRACTICAL OPERATION OF THE SUGGESTED AMENDMENT AND OF LEGISLATION TO BE ENACTED IN PURSUANCE OF IT.

Many of the countries on the Continent of Europe have had legislation permitting of a very complete development of the resources of the State, so far as this may be done by the use of water, for many centuries; and a reference to the forms that such legislation has, in course of time, come to assume, is, no doubt, instructive as to what may be expected of a constitutional amendment authorizing similar legislation in this country.

It may be said, in passing, that the situation in England is not especially instructive in the matter now under examination. There, as has been said, "the powers of Parliament are so transcendent and absolute that they cannot be confined, either for causes or persons, within any bounds."

On the Continent of Europe the matter of expropriation for the public benefit is well regulated by statute, and in certain lines has existed from the times of ancient Rome.

Thus, Frontinus' description of the aqueducts of the City of Rome, written A.D. 97, contains many references to the exercise of the right of eminent domain for purposes of building aqueducts.[1]

The Digest (43-20-8, 8-3-21, and 8-1-9) deals with the right of carrying irrigation, or drainage ditches, through the lands of others; and the form of restriction, in the last-cited law, which exempts a man's domicile, vineyard, etc., from the taking for a right of way for such water channels, unless necessary for the purpose, has remained in force in Italy to the present day.

In Niebuhr's German translation, 1840, of Romagnosi, "On the Law of Conducting Water," used in the preparation of this reference, the subject is treated at length on page 156.

[1] NOTE.— Frontinus, though in turn a surveyor, soldier and waterworks commissioner, gave much attention to the law of water-rights, which then, as well as now, no conscientious supervisor or administrator of hydraulic properties could afford to neglect. So that it has come about, that nearly all that is now known of the sources of the Roman law, as it treats of water-rights, and as laid down in the well-known work, Brun's *Fontes*, is taken bodily from Frontinus' pamphlet on the aqueducts of Rome. Similarly, Baird Smith, Royal Engineer, on "Italian Irrigation," deals as much with the law of waters and of the needs of legislation in East India, as with actual works of irrigation. So, also, Moncrieff, another Royal Engineer, who has since become the regenerator of Egypt, and is still at work there, in his book entitled, *Irrigation in Southern Europe.*

In Italy, legislation of this kind dates from the Milan Statutes of 1216 and of 1396. Says Romagnosi: "In forms of society not very fully developed, the principle of mutual agreement, together with the necessities of drainage, are the ruling circumstances. The right of traversing the lands of another against his will, with proper compensation paid to him, is the beginning of a more fully developed state of society; as was first exemplified in the case of Italy several centuries ago." In another place he calls the re-enactment of these and similar statutes "some of the benign works of the Renaissance."

Law writers of other nationalities speak of these statutes in the like commendatory terms. Thus Peyrer, in his commentary on the water-law of the Austro-Hungarian Empire, in commenting on an article of similar tenor in the Austrian code, speaks of the Milan Statutes of 1396 as model legislation, since they embody the "celebrated principle of the free passage of water-channels across the lands of third parties in consideration of payment of the value of the land occupied and of other damages."

The Civil Code of *Italy*, in so far as it relates to water-law, is given very completely, inclusive of legislation of the year 1883, in "Irrigation Development," by Wm. Ham. Hall, State Engineer of California, a State document printed in 1886. It would make this letter too long to quote its pertinent provisions at this time. But it presents a vivid picture of a just system of the exercise of the rights of eminent domain for the development of the resources of a Commonwealth; and engineers well know that the agricultural and other hydraulic works which keep alive the present population of Italy could not have been built without such laws; also, that similar works cannot elsewhere be built without the local enactment of similar laws.

The book, "Irrigation Development," contains also the Codes of *France* and of *Spain*, as they treat of the same subjects, and covering perfectly, and with great equity, all possible cases of necessary works for retaining, or excluding, or conveying water.

These laws ask to be known by their fruits; by the works built by reason of their existence, and blessing the countries that contain them from generation to generation.

This, then, is an appeal for a constitutional amendment which will permit of the enactment of laws of the kind just described, from time to time. In the firm conviction that it will tend to confer the greatest good on the greatest number, it is respectfully submitted to you and to the Constitutional Convention.

2 WALL STREET, NEW YORK, N. Y.,
March 10, 1894.

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TO

THE EXPLANATORY CHAPTERS

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